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# WATERJETS CUT THROUGH DNA

**Waterjet cutting joins BC Cancer Agency's Genome Sciences Center, and its fight against cancer – part of a worldwide effort to use advanced DNA sequencing technology for a better understanding of the unique molecular profile of individual patients' tumors.**

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Cancer patients receiving treatment at the BC Cancer Agency, Vancouver, British Columbia, Canada, have no idea that the same facility houses a working machine shop. This small, but well-equipped, shop plays a key role in supporting not only patient treatments, but also cancer research, in particular DNA sequencing.

The majority of work done at the shop involves producing fixturing for the hospital to position cancer patients precisely and in a repeatable fashion for different types of radiation therapy. Additionally, the shop does maintenance work for the hospital and its new in-house cyclotron, and will prototype and manufacture components for local medical research labs, including the Agency's Genome Sciences Center (GSC).

A robot, nicknamed Barracuda, is loaded with acrylic channel plates that will hold multiple DNA samples to automate the sample preparation process prior to DNA sequencing at the BC Cancer Agency's Genome Science Center. Many of the robot's parts, including the channel plates and LED-housing unit, are processed on an OMAX 2652 JetMachining Center.

The GSC is part of a worldwide effort to use advanced DNA sequencing technology to fight cancer by understanding the unique molecular profile of individual patient tumors. This, in turn, will guide treatment by helping doctors choose which drugs to administer for chemotherapy. A key to making this a routine treatment approach is efficient preparation of DNA samples from patient tumors and normal tissue.

The GSC is all about high throughput, processing as many samples as possible, as quickly as possible. It is currently the largest gene-sequencing center in Canada, and one of the top 10 such facilities in the world.

DNA sequencing, first shown in the 1970s, has been getting faster in the same exponential way that computers have. Completed in 2002, at a cost of $3 billion, was the Human Genome Project – sequencing of the first complete human genome's three billion base pairs. So-called Next-Gen sequencing methods, however, since 2006, have reduced that cost by about 10,000 times.

Researchers predict that by the end of 2011 it may be possible to sequence a human tissue or tumor sample for around $3,000. A big part of this cost reduction has been automation of the preparation process for DNA samples. One of the most effective recent automation developments at GSC has been a robot nicknamed Barracuda. The system automates a difficult step in sample preparation – selecting a particular size of DNA strands to put on the sequencing machines. The GSC's in-house engineering group designed it, with parts produced at the Cancer Agency's machine shop. The group relied heavily on abrasive waterjet cutting technology from OMAX Corp., Kent, WA, to manufacture a large portion of Barracuda's components and mechanisms.

The shop's OMAX 2652 JetMachining Center cuts everything from aluminum plate to stainless steel sheet material to plastics, such as acrylic and polycarbonate. In addition to waterjet cutting, the shop does CNC machining, fabricating, welding, and forming. It also has a small powder coating facility for manufacturing one-off parts to a finished state from scratch.


**An OMAX 2652 JetMachining Center speeds prototyping and component manufacturing in the BC Cancer Agency machine shop, which supports the agency and its Genome Science Center.**

GSC's OMAX 2652 JetMachining Center is a mid-size, cantilever-style machine that is set up to cut parts to tolerances tighter than ±0.003" (±0.08mm). Its ballscrew drive system is completely sealed and protected, making the machine very robust, reliable, and perfect for shops that work with small-to-medium dimensions, but need high precision.

The OMAX 2652 at the BC Cancer Agency shop came standard with an OMAX Maxjet5i Nozzle, and its work envelope X, Y cutting travels measure

52" x 26" (1,321mm x 660mm). The machine's table size is 69" x 30" (1,753mm x 762mm).

According to Dr. Robin Coope, PhD., and the GSC's engineering technology development group leader, the Barracuda project is a perfect example of the effectiveness of waterjet cutting, and of the speed advantage it provides in developing parts for custom automation.

While the Barracuda's X, Y, and Z stages themselves were repurposed from an older decommissioned robot, and mounted in a commercial extrusion frame (80/20 Inc), virtually all its other parts were waterjet cut from sheet steel and aluminum. These parts included the panels, electronic mounting structures, pumps, and camera and lamp mounts. Even the arrays of blue LED lamps (to make the dyed DNA fluorescent) were assembled from waterjet cut copper and steel.

In addition to other machining processes, the agency shop used waterjet cutting on what are known as channel plates, which have agarose gel channels where the DNA is separated. There are 12 of these 25mm-thick acrylic plates on the Barracuda's deck, each with eight channels. The outside of the plates were waterjet cut, including some very high aspect ratio slots that would have otherwise required a special operation on a CNC machine with a slit saw.

The inside channels of the plates, however, are CNC machined with one vise-fixtured operation. In addition, Dr. Coope says that the correspondence between waterjet cut part features and the CNC program was so exact that the same program could be used to chamfer those feature edges on a CNC mill.

He adds that, if the shop did not have this waterjet cutting capability, the development of the 12 prototypes leading up to the final version of the channel plate would have been at least twice as long because of the more complex fixturing that would have been required for other machining processes. Waterjet cutting allows his team to prototype or manufacture in small quantities anywhere from two to 10 times faster.

For another automation project at GSC, Dr. Coope's team used the OMAX waterjet system to solve a DNA sample transfer problem on a different robot. The solution was a specially designed, aluminum, stepped-shape top plate component that stops the rubber tube caps in a 96-tube plate array, measuring 8" x 12", from holding on to the robot's pipette tips, potentially breaking the robot's Z-axis from the force.

The rubber caps are atop individual tubes for a machine that breaks DNA into smaller sizes by ultrasonic waves. Once complete, a sample-transfer liquid-handling robot transfers the DNA from the tubes to reaction plates, and this is where the problem occurred.

Abrasive waterjet cutting played a key role in producing parts, such as these channel plate assembly components for holding DNA samples, used by the Barracuda robot at the Genome Science Center.

The robot's multiple pipette tips would simultaneously pierce the rubber caps of the tubes to draw the samples for transfer. As the tips began withdrawing, they would stick to the rubber caps.

Dr. Coope's top plate design incorporated a stepped shape that keeps the tube caps in place by staggering the upward pressure caused by all the pipette tips rising at the same time. The top plate has holes for each injector to pass through to the samples, and most of the part's features were cut using the waterjet. Dr. Coope points out that this saved time by eliminating CNC milling operations, allowing for greater utilization of the automated sampling system to increase throughput.

**PERFECT FOR PROTOTYPING**

"The OMAX waterjet system, especially for prototyping projects, allows us to quickly make parts that require few, if any, secondary operations," Dr. Coope says. "The more we can do to eliminate CNC milling the better, because it makes our prototyping more efficient and productive."

He states that there are applications that require CNC machined finishes, but they are rare. When such finishes are called for, the shop will waterjet cut as much of the part's near-net shape as possible to speed the overall machining process.

In the past, Dr. Coope's team would design and prototype components, and then CNC mill them from blocks of raw material out of necessity. Then Dan Gelbart, a friend of Dr. Coope who is an engineer and inventor, showed Dr. Coope the OMAX waterjet cutting system in his basement prototyping shop.Dr. Coope then realized how critical and beneficial waterjet cutting could be to prototyping. The machine's capabilities would complement other processing tools, such as press breaks and welders, to benefit manufacturing done for the GSC lab.

"We have broken away from the mindset of always starting with a block of raw material. Waterjet cutting allows us to accomplish so much more using sheet materials, which historically had never really been the case for prototyping in this center or other research facilities," Dr. Coope explains. "Two-dimensional sheet material is easily transformed, shaped, bent and welded into 3D struc-

**The BC Cancer Agency's machine shop uses its OMAX 2652 JetMachining Center to fabricate many lab accessories that help improve and streamline workflow at the Genome Science Center. One example is stainless steel racks that hold lab plates for machine washing and sterilization.**

tures. Such fabricating work was never considered for our prototyping until we got the OMAX waterjet cutting system."

In addition, Dr. Coope says that waterjet cutting requires designs to be somewhat less complicated than they would otherwise have to be, because of the cutting system's inherent 2D nature. Most importantly, the system is extremely user friendly, and the technology behind it is simple. Those with little machining experience are quickly trained on how to program and run the equipment, and the more direct experience in actually using the machine the more knowledge is gained in computerized fabricating, Dr. Coope adds.

"The OMAX machine is safe and tough to break," comments Dr. Coope. "This is unlike conventional CNC equipment, where a machine is powerful enough to destroy itself. A CNC milling machine can be severely damaged in the blink of an eye if the user makes one mistake. Waterjets are very forgiving, and it is easy to recover from mistakes with the system."

Dr. Coope attributes the simplicity of the 2652 waterjet, in part, to OMAX's state-of-the-art Intelli-Max software system, designed specifically for abrasive waterjet machining. He says that going from print to finished product is straightforward, and for 99% of the work the shop does, the software provides more than enough programming power.

"Conventional CNC machines have a long way to go to provide the current level of usability of OMAX waterjet machines," Dr. Coope says.

Waterjet cutting helps to speed the prototyping process at BC Cancer Agency's machine shop, mainly because of the technology's low cutting forces. As a rule, the less time spent on setups in the prototyping world, the better. Dr. Coope adds that in high-production situations, fixturing makes manufacturing more efficient, but in prototyping work and low-volume jobs, fixturing kills part cycle times.

Being able to interrupt prototyping jobs is another benefit of the simple setups on the waterjet machine. If a high priority job comes in, Dr. Coope and his team can quickly switch out the current work on the machine to run the hot job.

Dr. Coope also places great value on being able to do in-house powder coating, mainly because parts can be made and given a final finish in a matter of minutes. This not only means that prototypes can immediately become final versions, but it also has a greater impact in convincing a non-technical audience that a proposed prototype is real and going to work.

Waterjet-cut surfaces, according to Dr. Coope, lend themselves well to powder coating. When the shop conventionally machined parts, it had to spend extra time to achieve the same perfect-looking surface finishes. Even then, the machined surfaces gave the impression that the prototype was not really complete unless the part was anodized or otherwise finished. Powder coating covers small surface flaws so the advantage is realized at the machining stage, not the finishing stage.

As DNA sequencing becomes more of an integral part of cancer treatment, facilities such as the GSC and the Cancer Agency's machine shop will continue to grow and expand to serve patients. Production for both facilities will have to quickly ramp up to meet these patient needs, and Dr. Coope sees more abrasive waterjet machines, such as the OMAX system, coming on board to help. **tmd**

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