

Raising the Bar

Ontario machine shop develops unique approach to machining large propeller blades and waterjet impellers

Imagine a casting weighing 1,600 kg arriving in your 9,000 sq ft facility. Then imagine machining that casting on a simultaneous five axis milling machine to create a propeller blade spanning 2.3 m wide by 1.7 m high with surface roughness better than 63 micro in. roughness with surface precision within +/- 0.012 in. several times better than the ISO Class S tolerances required by the Canadian or US Navy. And imagine doing that in one setup on one machine, without the need for hand grinding and hand polishing.

That's exactly what Dominis Engineering Ltd., a Gloucester, ON, machine shop is doing.

"The original goal was to machine propellers so there was no hand finishing, to machine to final form and finish," says Bodo Gospodnetic, who formed Dominis 25 years ago with his father Drasko, a naval architect and mathematician who worked for the ship laboratory of the National Research Council (NRC) in Ottawa, and is now Researcher Emeritus at NRC.

"To do this, we had to develop a system to handle this machining concept. Our objective was to machine all the surfaces on



A Canadian Patrol propeller blade machined in Dominis Engineering's facility.

propellers to very tight tolerances in one setup. Everyone thought we were nuts."

That changed though when father and son developed their manufacturing process called Integrated Propeller Manufacturing System (IPMS) and began to apply the machining concept to hydro turbine blades. In the early 1990s, Bodo Gospodnetic made a presentation to the US Navy and to large US propeller manufacturers.

"Shortly afterwards, the US

government modified the defense appropriation bill and added propellers as items that had to be manufactured in the US. That was in 1994 and that was it for us in the US."

But that didn't deter him. A self-described tenacious entrepreneur, he turned to hydro turbine manufacturers, pump manufacturers and the US coast guard, and landed jobs to machine hydro turbine blades, pump blades and propeller blades. Then in 2003, he bid on

an international tender for the machining of 20 propeller blades for the Canadian Patrol Frigate.

“We won the contract against big international players and the reason we were able to win was because we underbid the competitors and the reason for that was our manufacturing system that is cost effective.”

Despite winning Canadian Patrol Frigate contract and subsequent other projects in recent years with companies such as Wartsila Defense, Rolls Royce Naval Marine, Atomic Energy of Canada, Bombardier Aerospace and Canadian and US Coast Guard, Gospodnetic says he still faces skepticism among some people.

“It’s because of the size of our company. We’re small. But how big should we be? We have 14 people and a 9,000 sq ft facility with three, five axis machines and one vertical

boring mill. I have a QA manager, a marketing manager, six machinists, five engineers and me. You don’t need many people to do what we do.”

Dominis Engineering has persevered and today, he says his company is the only one in Canada that meets Navy specifications for propellers and waterjet impellers.

Unique manufacturing system

The Integrated Propeller Manufacturing System (IPMS) has five guiding principles, explains Gospodnetic. All propeller surfaces (face and back profiles, leading and trailing edges, trailing edge chamfers, tip profiles, fillet--pressure and suction sides--and propeller hubs) must be machined to a “final form and finish.” It is an unattended operation that requires cutting tool efficiencies and the elimination of collisions between the tool body,

Canadian Patrol Propeller Blades

Machining Parameters

- CP blade surface area/side: 2.2 m²
- Blade length: 1.6 m
- Average width: 1.4 m
- Selected cutter diameter: 1.25 in.
- Distance between cuts: 0.625 mm
- Depth of cut: 2.0 mm
- Cutter rpm: 6285
- Feed rate for cutting: 6 m/min



Total cutter trajectory length and machining time for finish machining of CP propeller blades

- No. of cuts per side: 2560
- Length of cuts per side: 3584 m
- Cutting time per side: 9.96 hours
- Start/stop acc/deacc. time per side: 2.84 hours
- Feed rate in air: 10 m/min
- Climb milling only: cutter return in the air
- No. of return “cuts” in air per side: 2560
- Length of cuts in air per side: 3584 m
- Time in air per side: 5.97 hours
- Start/stop acc.deacc. time per side: 2.84 hours
- Grand total CNC machining time: 43.22 hours



MACHINING | Large Parts

propeller casting and fixtures. And while IPMS has “propeller” in its name, the same concept is applied to waterjet impellers and turbine blades.

The biggest challenges faced when machining these components is maintaining consistent tight tolerances over large surface areas. Dominis is able to achieve this with its IPMS system, but that system is dependent on having the correct CAD/CAM system capable of producing the right toolpath for machining complex, sculptured surfaces, machine simulation and toolpath verification software, the right type of machine and specific cutter geometries (ball nose end mills, face mills, button mills, and plunging cutters).

Dominis uses Open Mind’s HyperCAD and HyperMILL software, as well as Mastercam. “The surface of propellers are defined in a collection of patches. For example, the edges of propeller blades are defined separately from the face, back and hub and they all have to be stitched together, so the CAD program needs to have the ability to create a smooth transition for machining of all these components.”

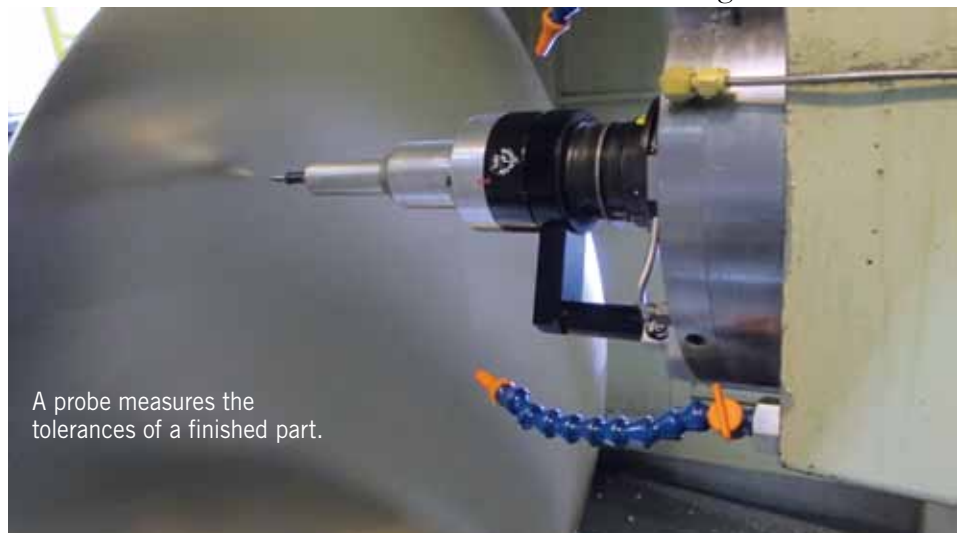
Post-processed CNC programs are run through a true machine simulation software system. “We make extensive use of Vericut software (from CGTech) for toolpath verification,” adds Gospodnetic.

The right machine for Dominis is a simultaneous five axis CNC milling machine designed with large travels of 2.5 m in the X axis and 1.8 m in the Y axis.

“What I like best about these machines is that they feature fast



Dominis Engineering’s innovative approach to machining means the shop can achieve tight and consistent tolerances over large surface areas.



feed rates of 6 m/min and have a high speed spindle of 8,000 rpm. Another good thing is that the spindle is on a programmable quill so I can move closer to the part; it’s 200 mm in diameter and 450 mm long. It’s like having a tool extension that’s 8 in. in diameter.”

Special tools are a must to achieve what Dominis does. “For example, if you’re machining very thin edges on a blade, you’re likely to destroy that edge if you’re machining it with ball nose end mills. We’ve developed some tools where we can machine thin edges; they’re specially designed end mills. We purchase carbide

inserts with the geometries we need and then build the cutting tool,” explains Gospodnetic.

Dominis isn’t done refining its machining process. “We now run mostly unattended because of our process but one of the elements you also need is tool replacement options on the machines capable of detecting when a tool becomes dull and that can then replace the tool with an identical new tool in the tool magazine.” If it’s not

identical, it is trouble because you’re machining sculptured surfaces and these surfaces are defined by discrete points and you have to interpolate the surface, which is smooth between defined points.

“We’re not there yet, but tool measurement and tool replacement options are the next step for us when we purchase a new machine.” SMT

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