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Technology: New Nozzles Improve Northern Tug

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Northern Transportation Company Ltd. of Hay River, Canada, recently completed a major refit of one of their quad screw pusher-towing tugs, the Edgar Kotokak. Vancouver's Robert Allan Ltd. provided design and engineering services for the refit which improved the operational efficiency of the tug. The refit included new CAT 3512B engines and replaced the open propellers and rudders with integrated Nautican Nozzles and Triple Rudders. The results says Mike Whittaker, Captain of the Edgar Kotokak, are "superb."

Although total engine power increased from 4,500 to 5,640 hp on the Edgar Kotokak, and obviously bollard pull trials showed improvement, anecdotal evidence from the first month or so of operation seems to indicate that both the nozzles and Triple Rudders together with the new engines have improved the overall fuel efficiency. As one of four of NTCL's 'tower tugs', this refit is also allowing a comparison of open propellers to both Kort and a type of high efficiency nozzles.

Originally designed by Robert Alllan Ltd. (RAL) and built in the 1973, the 153 foot long Edgar Kotokak had, as her sistership the Henry Christoffersen still does, four open propellers in tunnels for propulsion with twin, transom hung rudders behind each prop for steering. The other tugs, the Kelly Ovayuak and Jock McNiven, use four Kort Nozzles in tunnels, each with twin rudders aft inside the tunnel. All the tugs originally had the same engines.

NTCL is a pan-Arctic marine operator, providing comprehensive marine transportation and related services throughout Northern Canada and the Arctic. The Edgar Kotokak works on the Mackenzie River between Hay River and Tuktoyaktuk during June, July, and after October 1st. In August and September, ice conditions improve enough that it also works in the Beaufort Sea and Coronation Gulf.

Working in the Mackenzie River poses many problems. Pat Williams, Manager Marine Engineering, Western Arctic, for NTCL, says, "there's a lot of shallow water. In dry years it can be really difficult, not only does the depth decrease but the channels narrow as well. Coast Guard does a good job with Aids to Navigation, marking the channel, but no one does any dredging." And the river level can vary substantially in a given year. "I've seen it fluctuate 8 ft. in a week," says Williams. Another problem is rocks and ice going through the propellers and rudders.

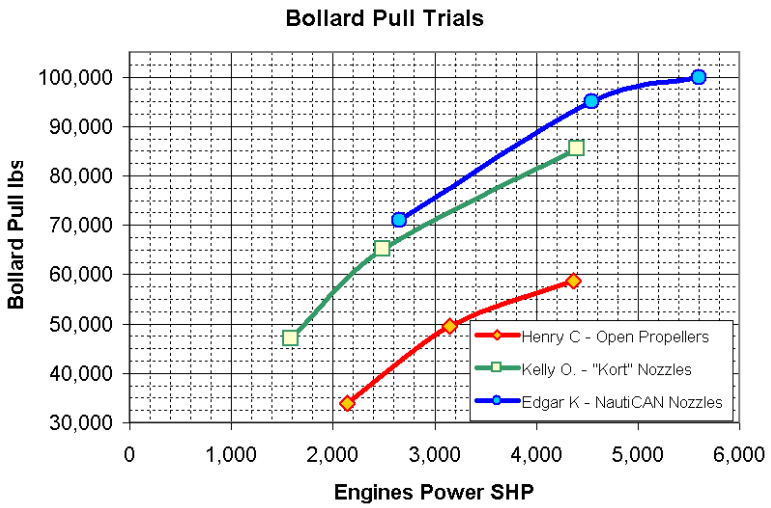
Going up- or down-river each present their own problems. Typically the tugs push, from the middle aft barge, two rows of three barges abeam. Because the Mackenzie flows so fast, including parts where the current averages 5 to 6 knots, going downstream is not taxing on the engines, but is a challenge for keeping the barges in the channel. There are also about four areas, where the rapids are fast enough that the tows have to be broken up before can proceed though them. Going upstream can be difficult because more horsepower is required; although going against the current slows things down, allowing the tows to consist of up to 4 rows of three barges across.

Williams provides an example of the difficult areas. "There's a rock shelf in the river just before Fort Good Hope, called the 'Ramparts'. In dry years the boats have to actually push the barges uphill. You can see the angle they make as they go over." This led to one observation on the differences between open propellers and ones in nozzles. He reports that, "Only the nozzle boats could push the bigger barges through."

The second observation was on the maintenance of the rudders. Behind the open propellers, the rudders are, states Williams, "very high maintenance because of vibration. The linkages and pins needed replacing every two years. They are also susceptible to being knocked off, both from the props spitting ice through and by backing too close to the river banks. We noticed the rudders on the Kelly O. have only needed the pins changed once in 30 years."

The refit was undertaken because says Williams, "the hulls are fine and the design works well but [engine] parts are starting to be a bit of an issue. We also wanted to upgrade the capacity to save time." He adds, "It looks like the [Mackenzie Valley] pipeline is coming, and we are getting ready." So besides all four CAT D399 V16 engines (1,125 hp at 1,225 rpm) being replaced with CAT 3512B Electronic engines (1,410 hp at 1,600 rpm) and the 56-in. open propellers along with each's twin rudders replaced by 58-in. integrated Nautican Nozzles and Triple Rudders, new custom Lufkin transmissions and a Jastram twin-independent steering system were installed.

One reason Nautican's nozzles were used was NTCL was happy with the improved performance that resulted after the retrofit of Nautican Nozzles to their three arctic class vessels. Additionally, Williams reports that, "the nozzles take a beating because they bounce off the bottom and rocks get spat through. And they've stood up well though that." Joe Gruzling, President of Nautican Research and Development Ltd., agrees, "it looks like they stand up very well to the bouncing on the bottom." He says this is, "due to their solid construction with no plug welds."



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For shallow water operation the boats have tunnels to be able to use larger diameter propellers. Following the tunnel contour longitudinally aft along the hull bottom, the surface of the tunnel actually rises to above the waterline where the propeller located before descending again to below the waterline to prevent the propellers from sucking in air. Gruzling suggests the tunnels produce, "lots of performance losses, especially in shallow water," because the props are limited where they can pull water in from.

As well for shallow river operation, the Kelly Ovayuak and Jock McNiven's Kort nozzles are not the standard 19A profile, but the type 22 profile. According to Gruzling, the type 22 is similar in profile to the type 19, but with a larger length to diameter ratio. The result is, "slightly better bollard pull, but much greater drag and therefore worse performance at higher speeds proportional to the length." Gruzling had to adapt his Nautican Nozzles for the shallow water operation as well. "The bottom of the nozzle is flattened and a large segment of the nozzle is buried in the tunnel."

This installation is the first shallow draft application of the Nautican Triple Rudders and the first time that Nautican has supplied the nozzles and Triple Rudders integrated as one unit. Gruzling explains, "The nozzles are built with a head-box that housed the rudders together with the rudder stock, bearings, links and seals. The rudders are mounted on a removable cover plate to have access for replacing propeller. The idea is it saves a lot of shipyard installation time." Williams agrees, "It was a very easy installation and definitely saved time."

Chris Mulder, Senior Project Engineer at RAL, supervised the bollard pull trials on the Hay River. The accompanying figure shows that not only do the larger engines produce more thrust as expected, from 60,000 lbs to over 100,000 lbs, but the Nautican Nozzles produce more thrust at the same horsepower, almost 60% over the open propeller and 10% over the Kort nozzle at 4,400 hp. However the data from this test is not complete.

Mulder explains that as there is no one mooring strong enough and close enough to deep water to take the 100,000 lb pull, a large barge with a strong enough bollard was tied off to several points on shore to act as the 'immovable object'. The Edgar Kotokak was positioned about 300 ft. away at a 45E angle to shore to both be in deep water and line up with the barge. He reports that it was a bit tricky keeping the tug and barge lined up in the current. The next problem was the tug's prop wash being so large as to start backing up the river, creating all sorts of weird eddies, one of which set another barge on the opposite bank free, temporarily halting the tests. After restarting, the mooring lines of the large barge began to break, stopping the tests altogether including ones for measuring the astern bollard pull. Gruzling thinks these latter tests would have shown an even better performance comparison for the Nautican Nozzles.

Captain Whittaker reports that you can see the difference the nozzles make. "With the open wheel, the boat had a rooster tail. Now [the nozzles] are putting the power in the water. We've added two knots to the top end speed, we get 14 knots now. The Kelly O. and McNiven are lucky to get 12." He also says that, "even with the bigger engines, its more fuel efficient." He has one example, "On an 1100 mile trip we saved a day and a half in time and a day and a half of fuel which adds up to three days of fuel."

Williams is taking a more cautious approach in deciding whether the tug is more efficient, preferring to wait until he has all the numbers at the end of the year. But he does admit the tug's, "utilization is already higher." Gruzling estimates that, "the NautiCAN Nozzles should be 10-15% more efficient at towing speed than the Kort Nozzles and I think the engines are 5-10% more fuel efficient. But great savings will also come from the Triple rudders, from not having to reverse the engines on one side when turning around the bends on the river."

The much improved manoeuverability is a surprising bonus for NTCL. Williams explains why its so important and what happened. "When going down river the tow needs to get split up at four spots to go through rapids. To split up the tow, they have to stop and tie off some of the barges and to do that, they have to turn 180E upstream first. All the other boats, including the McNiven and Kelly O., will start setting up to spin the tow .5 to .25 mile before the tie-up depending on the tow and current conditions at the location. With the Triple rudders [the tug and tow] turn right now. The first time they were operating the boat, one crew went to turn a quarter mile before the tie-up, and they finished turning a quarter mile before the tie-up."

Whittaker has had similar experiences, "She turns on a dime. It can stop 6000 tons of freight, turn in its own length, all going down stream. And this is when there are two rows of three barges, so its 700-ft. long by 165-ft. wide. With the split rudders I put one ahead with the rudders hard over and the other astern with the rudders amidships. Half way around at 90 degrees I put the one going astern into neutral, otherwise we get dragged away backwards from our target."

So it appears a high efficiency nozzle, in this case a Nautican one, offers huge performance improvements of up to 60% over open propellers, and a substantial improvement of 10% or more over the usual Kort Nozzles, even in a challenging river application. As Mulder puts it, "It's a no-brainer from a performance point of view to put nozzles on these very shallow draft vessels." The nozzles and Triple Rudders have also greatly helped the boat in the difficult river environments because now, as Whittaker puts it, "she handles well."

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