Sticky Wickets

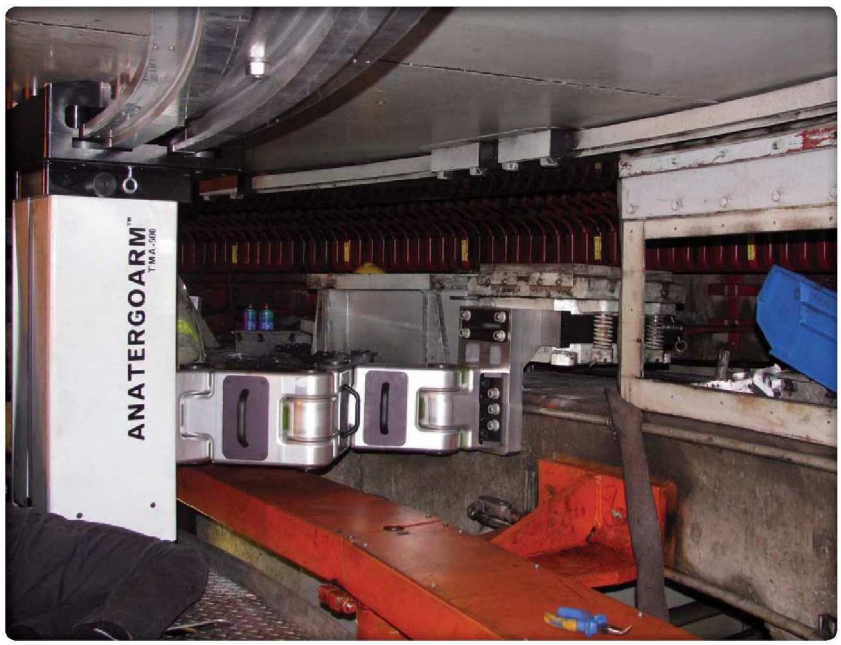
Arm Allows Brake Unit Repair at Hydro-Quebec Facility

Minimal working space under the generator rotors at Hydro-Quebec's 5,328-MW Robert-Bourassa Generating Station was one of the factors that made brake unit repairs an expensive challenge. As a result, the Canadian provincial utility looked for a solution that would minimize risk to workers performing the repairs while also shortening the amount of time required. Hydro-Quebec now plans to use Robotics Design Inc.'s Anatergoarm TMA-500, a snake arm specialized for the removal of brake units and their reinstallation after repairs, at this facility.

Understanding the problem

Repair of brake units is a common occurrence at hydroelectric facilities. However, limiting physical conditions in the plant often complicate this task. One example is Hydro-Quebec's Robert-Bourassa station, which is part of the La Grande complex on the La Grande River. The underground powerhouse contains 16 turbine-generating units that were commissioned between 1979 and 1981. At this facility, Hydro-Quebec's maintenance schedule calls for overhauling the brake units every 15 to 20 years, depending on the number of unit start-ups and shutdowns.

Hydro-Quebec employees' greatest challenge in performing this work at the Robert-Bourassa plant involves moving about in the cramped and crowded room under the rotor in which the brake units are located. This 4-foot-high, obstacle-laden space is inaccessible to large machinery, so workers have to crouch into this space to reach the brake units. Twelve brake units are located under the rotor in each turbine-generating unit and must all be manipulated through just 2 feet of obstacle-free space.



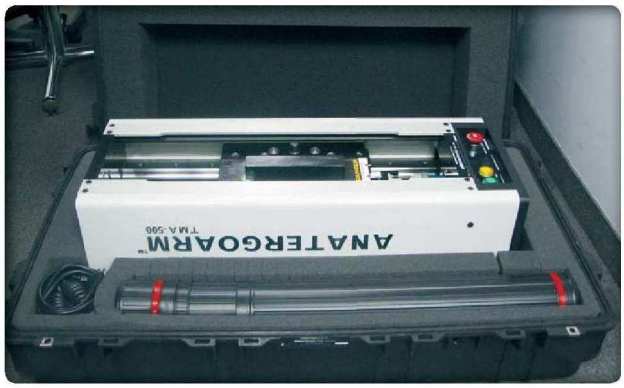
Hydro-Quebec uses the Anatergoarm TMA-500, a snake arm specialized for the removal of brake units and their reinstallation after repairs, at its 5,328-MW Robert-Bourassa facility.

The device used to perform these repairs at the Robert-Bourassa facility was a makeshift solution developed by Hydro-Quebec mechanics in the mid-1980s with no engineering approval. It was unsafe and was unable to move the 340-kilogram brake units outside the turbine pit. For a complete overhaul, brake units must be removed from the pit and taken to a machine shop. For minor repairs that can be performed *in situ*, the brake unit must be repositioned to allow workers to reach its internal components.

Because the existing tool was inadequate to remove the units, repairs had to be performed manually under the rotor. Minor repairs, such as cup replacement, took about a day with two mechanics. But this work required that the mechanics lift parts weighing more than 50 pounds. Once, more than 15 years ago, a brake fell from the device and broke a mechanic's arm.

Hydro-Quebec wanted to find a way to perform this work that would ensure employee safety as well as reduce the resulting extended generation outage necessary to allow these repairs to be performed. For example, the generating units at the utility's La Grande 2 facility have been in service for 30 years, and upcoming scheduled brake jobs will consist of major repairs. Each generating unit has 12 brakes, and in total the brake work is estimated to require nearly 500 person-hours. This will result in a total cost of about $150,000 (including hardware).

In addition, the 2009 Occupational Health and Safety Act tightened Canadian worker safety standards. This further encouraged Hydro-Quebec to investigate safer alternatives for manipulating the brake units at the Robert-Bourassa



The Anatergoarm TMA-500 snake arm arrives in portable cases for easy assembly and storage.

plant. A flexible, powerful, and safe solution was needed that workers could deploy and redeploy quickly.

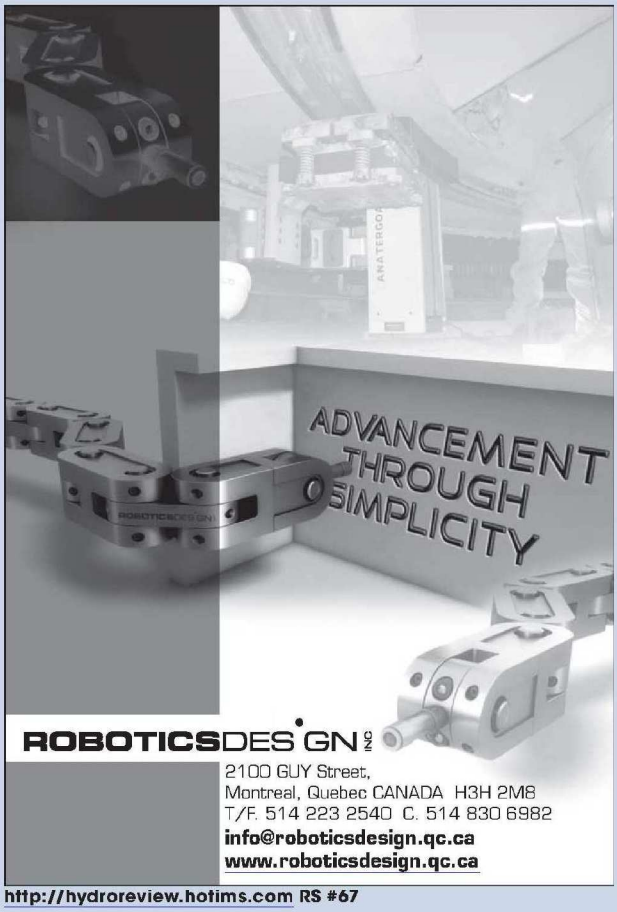
Investigating alternatives

Hydro-Quebec investigated several alternatives to deal with this situation, including adapting existing tools used at other hydro facilities. However, each generating station has unique units, and the tools used elsewhere could not be used for Robert-Bourassa. Personnel also requested assistance from internal engineering advisors at the utility's Shawinigan machine shop. They had crafted many tools for the Robert-Bourassa facility in the past, but they were unable to offer a solution to this complex problem.

During this investigation, Hydro-Quebec personnel met with Charles Khairallah, chief executive officer of Robotics Design and creator of the Anatergoarm snake arm family that includes the TMA-500 (turbine maintenance arm) model. The Anatergoarm TMA-500 is a mobile maintenance and repair package that can navigate multiple obstacles while carrying up to 500 kilograms.

The ANAT (articulated nimble adaptable trunk) technology on which this arm's design is based allows entire robotic systems to be made from identical U- and H-shaped modules. This simple design gives modules the capacity to withstand pressure from all directions, similar to the design of the Roman arch.

The four modules that form the TMA-500 arm are jointed on their axes, allowing them to bend around obstacles with serpentine flexibility. Because modules work together like a body's cells, pressure from the payload is evenly distributed throughout the entire arm, which allows longer arms to maintain



the same payload-carrying capacity as shorter ones. The arm is made with 85 percent aircraft-grade aluminum and 15 percent heat-treated steel to provide durability and longevity while minimizing equipment weight.

Using the Anatergoarm, a single worker can manipulate objects simply by grabbing the ergonomic handles and pushing the arm and attached payload in the desired direction. This work is performed without power consumption for horizontal movements because of the Anatergoarm's no-gravity design, while the arm moves vertically within the height of the base at the push of a button. To move objects around the turbine, the arm's base is made mobile along an aircraft-grade aluminum rail. At Robert-Bourassa, the rail will be deployed in a circle around the base of the rotor.

Using the equipment

The Anatergoarm TMA-500 equipment and rail arrive ready-to-assemble in five portable cases. To satisfy security requirements at Hydro-Quebec facilities, complete installation of the equipment was performed by three workers in two days. Hydro-Quebec performed acceptance tests of the Anatergoarm TMA-500 at Robert-Bourassa in October 2010. This testing showed that the device could be used from the start without requiring adjustments.

In addition to brake unit repair, the Anatergoarm TMA-500 can be used for other turbine maintenance and manipulation work around the plant. Heavier loads can be manipulated by deploying a second arm working in unison with the first, which also doubles the arm's carrying capacity. A forked loader accessory at the end of the arm serves as a standard loading platform, which can be replaced with new accessories for different applications.

— By Steven Scanlan, head of marketing and communications, Robotics Design Inc., and Daniel Cote, mechanical technician at Hydro-Quebec's Robert-Bourassa Generating Station

The popular "Sticky Wickets" department features practical solutions to operating challenges in hydro facilities. Do you know of a problem that has been solved using a creative solution?

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