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Diakont technicians prepare an NDE inspection robot for deployment into a diesel tank. Photos: Diakont

Robotics for plant maintenance: NOW AND IN THE FUTURE

By Tobias Haswell

Robotics and remote systems have been used for supporting nuclear facilities since the dawn of the atomic age. Early commercial nuclear plants implemented varying levels of automation and remote operation, such as maintenance activities performed on the reactor pressure vessel and steam generators. Over the past several decades, there has been a steady progression toward incorporating more advanced remote operations into nuclear plants to improve their efficiency and safety. One of the primary forces driving the adoption of robotic tooling in U.S. nuclear power plants is money.

The economic model for the U.S. operating fleet has changed considerably over the past 10 to 12 years. Regulations in the nuclear industry have rarely decreased and, more often than not, have increased. This has led to nuclear plants in certain energy markets being hindered financially and thus needing to find ways to optimize their operations to do more with the resources they have. At the same time, the reliability and flexibility of robotics and automated systems have been increasing while their costs have been decreasing, making robotic systems much safer and more available to use. This has helped drive utilities to explore new ways of using robotics to overcome the obstacles they are facing. One of the obstacles that power plants have been tackling has been shortening the duration of their refueling outages to decrease their costs and increase their revenue.

In the past, outages may have lasted a few months, whereas now some take only a couple of weeks. In part, the decrease in the duration of the outages has been a result of improvements made to the operation of the plants, which has included the implementation of robotic and automated systems. In some cases, the use of robotics has allowed operations that previously needed to be done in a linear order (one after another) to now be done in parallel, which has the potential to cut hours or days off of outage schedules.

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A decontamination ROV on a dry surface and in action in a refueling cavity.

One example of this is the use of a submersible ROV (remotely operated vehicle) that my company, Diakont, uses to perform remotely operated robotic decontaminations within the equipment pits and reactor cavity pools during fuel moves.

During the outage, the reactor is disassembled so that the plant can access and move the fuel rods located within the reactor. To protect plant personnel from radiation during this time, the equipment pit and reactor cavity pools are flooded with water, which helps to shield the personnel from the radiation. While the water is protecting the personnel from radiation, it is also spreading contamination from the fuel rods onto the surfaces within the pool. Toward the end of the outage, these pools will need to be drained so that personnel can go into them and perform work on the reactor pressure vessel head.

Before the work can be performed, the contamination must be removed from the surfaces inside the drained pools. Traditionally, this has been done by hand by human technicians after the water has been fully drained.

The benefit of using an ROV to decontaminate these pools while there is still water in them is two-fold. First, because the surfaces are being decontaminated in parallel with the fuel moves and other refueling activities, the plant can save a significant number of hours in its outage. Also, any contamination that is remaining within the pools after the drain down is drastically reduced, with radiation levels that could be 50 percent of what they would have been otherwise. By using a robotic solution instead of human technicians in this case, plants can reduce costs while also improving safety.

Improving the safety of existing plant operations has been another motivating factor for the introduction of robotic solutions. To minimize or eliminate the use of human divers, underwater robots are beginning to be used when work needs to be done in areas such as a suppression pool or an intake structure, which helps to reduce the risk of bodily harm to plant personnel. In addition, the use of industrial unmanned aerial vehicles (drones) can perform aerial inspections in minutes while also avoiding the risks posed to humans by the use of scaffolding or rope access. The use of robotics in these situations has removed humans from conditions that previously put them in danger.

New plant maintenance activities, not historically performed, are being conducted for the first time robotically. Examples of this include balance-of-plant inspections required in accordance with an aging management program or regulator commitments from license renewal. Diakont provides robotic solutions for many of these new activities such as inspections of storage tanks for refueling water, condensate, or diesel fuel. These inspections can be done without removing the tanks from operation and, in most cases, avoiding a Limited Condition for Operation. Diakont also performs robotic ultrasonic testing inspection of buried piping, needed to ensure the detection of any corrosion that could lead to leaks that would contaminate groundwater. Other new applications in the industry include the use of remotely operated systems to perform the inspection of dry fuel storage canisters from inside their overpack casks. The introduction of new neural network technology is being used to perform automated visual analyses of fuel assemblies in real-time, which can identify the presence of debris or foreign material that could lead to cladding leakage.

The pandemic this year has given a major push to the nuclear industry to try to limit the number of personnel allowed on-site. Many U.S. plants were impacted by the pandemic just as Spring 2020 refueling outages were starting. These plants were forced to begin looking for ways to adapt as quickly as possible to limit the number of personnel on-site, which was accomplished often by eliminating activities that were not deemed absolutely critical at that time.

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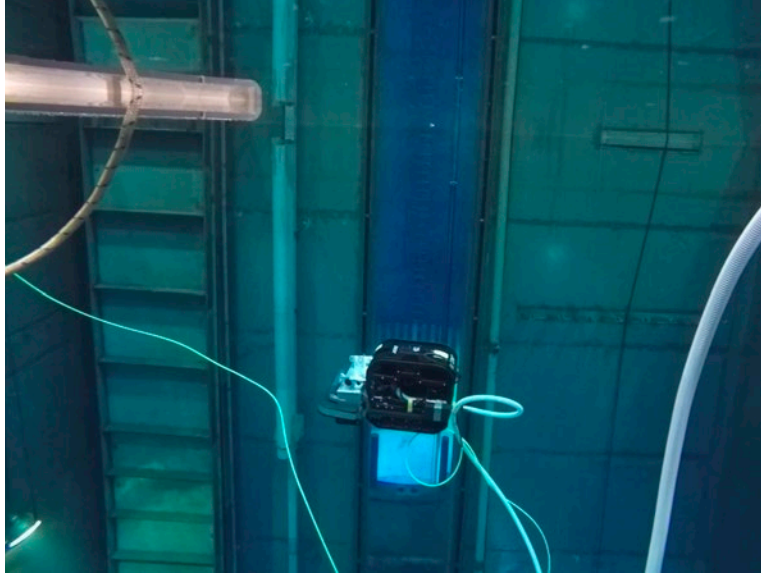

Right: An ROV in use at a test facility inside a mockup of a reactor cavity pool. The ROV can be employed into a variety of pools, most often in the reactor cavity pool and the equipment pit pool (also known as the dryer/separator pool). The ROV is capable of attaching and driving (using tracks) on both the walls and floors inside the pools. While it drives around, it also uses a brush to scrub the walls and floors, removing contamination, which is then sucked up a hose to a filtration pump. By doing this, the walls and floors are decontaminated in parallel with other outage activities, saving both time and dose to the personnel when the pools are drained during reassembly of the reactor pressure vessel.

However, these activities will eventually need to be performed. Remotely operated robotic solutions will be a great solution for eliminating the need for personnel to be involved in activities that typically would not allow for social distancing. It won't happen overnight, but nuclear facilities have already started looking into how to use robotics as an alternative. Looking forward, there will be a renewed, permanent push to do more tasks with robotics and remote tooling, even post-COVID.

The future for robotics in the nuclear industry is looking bright. With secondary license renewals, the current operating fleet of plants in the United States is now being licensed to operate into the 2050s—more than 30 years from now. If you consider that 30 years ago technology was still mostly analog, we can imagine how much the industry will grow in these next 30 years. In our current age, most maintenance activities still require personnel to perform them by hand. By leveraging future robotic technology that can navigate the existing stairs, airlocks, and catwalks of a plant, more and more maintenance activities will be able to be done by robotics while the plant remains on line. There may be a day when an untethered robot can go into containment for a 100-percent power entry. That robot will be able to withstand the radiation and temperature while using thermal imaging and LIDAR (light detection and ranging) to navigate. Checking potentially erroneous alarms, the temperature on a bearing, or replacing a faulty sensor are just a few of the advantages that this robot would provide. All the while, a licensed operator would be safely situated outside the radiologically controlled area. It is the application of technology such as this that will continue to increase the reliability and capacity factor of the existing fleet, allowing it to continue to meet our carbon-free baseload generation needs.

Whatever challenges the future may hold for the nuclear industry, one thing is certain: robotics will be leading the way in solving those challenges. New technology is constantly being introduced and obstacles are being overcome. Whether it's robots that fly, climb stairs, or swim underwater, the industry is abounding with new robotic solutions that will reshape how we think and how we perform services in the nuclear industry.

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Left: A UT robot is prepared by Diakont technicians for inspection deployment into service water piping.