AUTOMATION OF STEAM GENERATOR SERVICES AT PUBLIC SERVICE ELECTRIC & GAS

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ABSTRACT

Public Service Electric & Gas takes an aggressive approach to pursuing new exposure reduction techniques. Evaluation of historic outage exposure shows that over the last eight refueling outages, primary steam generator work has averaged sixty-six (66) person-REM, or, approximately twenty-five percent (25%) of the general outage exposure at Salem Station. This maintenance evolution represents the largest percentage of exposure for any single activity. Because of this, primary steam generator work represents an excellent opportunity for the development of significant exposure reduction techniques.

A study of primary steam generator maintenance activities demonstrated that seventy-five percent (75%) of radiation exposure was due to work activities of the primary steam generator platform, and that development of automated methods for performing these activities was worth pursuing. Existing robotics systems were examined and it was found that a new approach would have to be developed. This resulted in a joint research and development project between Westinghouse and Public Service Electric & Gas to develop an automated system of accomplishing the Health Physics functions on the primary steam generator platform. R.O.M.M.R.S. (Remotely Operated Managed Maintenance Robotics System) was the result of this venture.

R.O.M.M.R.S. is a fully integrated robotic arm, delivered on an overhead track and trolley system and using multiple end effectors (an "end effector" is basically an automated tool at the end of a robotic arm that, when activated, may accomplish a given task.) R.O.M.M.R.S. has successfully completed mock-up testing and will be implemented in Salem's fall Unit Two Outage for a complete field test and evaluation. R.O.M.M.R.S. will perform the Health Physics functions normally provided by radiation protection technicians (e.g., beta and gamma radiation surveys, air sampling, decontamination and job observation). Additionally, R.O.M.M.R.S. will attempt to do bolt hole cleaning, one of the many platform worker activities executed by maintenance technicians.

INTRODUCTION

With the increasing competition and rising O&M costs in our industry, the option of replacing steam generators due to tube degradation or in support of plant life extension, is becoming less and less an economic option. for this reason utilities will be striving to ensure that the steam generators they currently own will last the life of the plant. This implies that the scope of work and associated radiation exposure for primary steam generator maintenance will be increasing as plants step up NDE exams and other maintenance activities to repair degraded tubes. In an effort to address this concern, R.O.M.M.R.S. was developed with the intention of reducing labor requirements, increasing overall job efficiency, and decreasing radiation exposure associated with these activities.

R.O.M.M.R.S. System Overview

R.O.M.M.R.S. consists of a two degree of freedom ("degree of freedom" refers to any of a limited number of ways in which a robot may move) mobile base, delivering a six degree of freedom robotic arm. The mobile base is supported by a modular track system that can be configured to allow the robot access to a given area of interest. The robot is animated using a highly accurate three-dimensional computer simulation of the robot and its environment (i.e., the primary steam generator platform, etc.) on a Silicon Graphics Indigo 2® work station. The Indigo 2® was the computer used to create the dinosaur animation sequences in the film "Jurassic Park." This computer (located outside the Radiologically Controlled Area) is networked to a Robot Operating Computer so that manipulation of the robot model induces the actual robot to move in kind.

The 3D simulation is accomplished using a modified version of the ROBCAD® software. ROBCAD®, originally a robot design tool, provides the R.O.M.M.R.S. operator with the ability to initiate and view movements of the robot within its environment. This the first time that a 3D simulation has been used to control an industrial robot. Another breakthrough accomplished by the R.O.M.M.R.S. design team is the development of an software algorithm which can incorporate all eight (8) degrees of freedom of the R.O.M.M.R.S. mechanism. Recognizing that there is often a difference in dimensions between what is shown in plant drawings and what is actually in the field, the ROBCAD® system allows for easy re-calibration of the 3D model. By selecting several predetermined calibration points in the field, the robot can communicate actual locations of these points to the work station so that ROBCAD® can make appropriate adjustments in the model to correct the simulation to actual field dimensions.

ROBCAD® also provides collision detection for R.O.M.M.R.S., preventing damage to plant equipment, or to the robot itself. As additional field equipment is added to the environment, these obstacles can be accurately modeled into the simulation along with appropriated collision detection safeguards.

R.O.M.M.R.S. is able to perform multiple tasks by choosing from various custom designed end effectors. In order to perform health physics tasks, six (6) different end effectors were designed:

- General Purpose Gripper - three fingered claw used to grab objects as well as change air sample heads.
- Swiping Tool - obtains loose contamination samples.
- Beta Scanning Tool - surveys environment surfaces for beta radiation
- Telescopic Steam Generator Bowl Survey Tool - performs gamma radiation surveys of the steam generator bowl area.
- Decontamination Tool - performs decontamination of platform surfaces.
- Vacuum Tool - provides loose debris removal capability.

These end effectors are harnessless (another robotics breakthrough) to allow remote coupling and uncoupling.

Gamma detection is continuously accomplished by four integrated gamma detectors (SAIC® Commercial Products PDE-4™) located at the tool coupling. Radiological surveillance is performed by dividing an area into a grid of eight inch squares (this information is then recorded in the database of the 3D simulation) and moving the robot to each section of the grid, at planes of eighteen (18), thirty-six (36) and seventy (70)

inches above the surface (i.e., knee, waist and head readings). The readings are displayed and recorded at the work station.

Cost/Benefit

Public Service Electric & Gas and Westinghouse have been developing R.O.M.M.R.S. since 1991. By utilizing existing technologies, equipment and in-house expertise, the initial financial obligations for both parties were kept to a minimum. The total cost to Public Service has been a little less than two million dollars.

Salem station expects to get back far more than our initial investment through outage contractor staffing reductions and collective exposure savings. When fully operational, we expect to reduce our primary steam generator health physics coverage by at least three (3) ANSI qualified senior technicians per platform per outage. This equates to at least $100,000 savings per outage.

The collective radiation exposure savings will also be significant. Based on historical outage data, we expect to save five (5) to twenty (20) person-REM from our outage total. This indicates an additional savings of $50,000 to $200,000 based on $10,000 per person-REM.

Future Applications

Although R. O.M.M.R. S. is a stand alone system, its future allows for integration into other control systems. For example, the operator that is controlling the robot that gathers eddy current data inside the steam generator bowl, will have the ability to control R.O.M.M.R.S. from the same work station. This will allow control of both systems by one operator in a completely integrated system. The benefits of this integration are reduction of support personnel, and increased overall job efficiency by using R.O.M.M.R.S. to support the steam generator bowl robot (i.e., tool change out, etc.).

It is important to remember that industrial robotic applications have proven to be economically beneficial when ever the task at hand was either dangerous, dirty or dull and repetitive. These are the three "D's" of industrial robotics. The basic idea behind R.O.M.M.R.S., a modular track system which delivers a remotely controlled robot, is very flexible. The track system can be configured to allow the robot to go around corners and also move vertically. By adding track sections, the robot can travel as far as the applications requires. The track and trolley could be reconfigured to deliver any type of instrument, tool or monitoring device to an otherwise inaccessible area. Adding "bus bars" to supply power to the robot from the track would be simple to accomplish. This would allow the system to be completely free of wire and cables, thus providing maximum system flexibility.

A list of potential applications for R.O.M.M.R.S. is virtually endless. With the modular track design, a reliable field tested robotic arm capable of delivering any type of end effector, and the computer control system allowing easy performance of both simple and complex tasks with minimum operator experience, makes R.O.M.M.R.S. an extremely adaptive system. This system has application potential in present PWR and BWR reactor environments, advanced reactor designs, underwater applications, as well as any other hazardous environment.

Author Biography

John Wray is the Radiation Protection Manager at the Salem Nuclear Generating Station responsible for managing the Operational Health Physics, ALARA, and Radioactive Waste programs at this two unit PWR site. He has 21 years of varied nuclear power industry experience including assignments with a major architect engineering firm, the Nuclear Regulatory Commission and Southern California Edison's corporate office. John is a Registered Professional Nuclear Engineer and a Certified Power Reactor Health Physicist. Mr. Wray holds a B. S. degree in Nuclear Engineering from Rensselaer Polytechnic Institute and an M.S. degree in Environmental Health Engineering from Northeastern University.

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