ADVANCED DECONTAMINATION AND DECOMMISSIONING SYSTEM

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ABSTRACT

Radioactive waste packaging in many areas is handled manually with workers sorting the pieces and placing them into containers. Because of the risks associated with contamination and radiation levels, workers are not allowed to efficiently pack the waste in the container and are generally prohibited from reaching into or over the container walls. The effect is that containers are unevenly or partially filled, contain voids, or are off-balance. The workers may also not accurately manifest the waste in each box. This ultimately results in using more containers to store and dispose of the waste than is necessary and may require reopening of a box if additional characterization is required. With high disposal costs, there is a strong incentive to minimize the waste volumes.

The Advanced Decontamination and Decommissioning System (ADDS) is a tool which will aid in dose reduction, contamination reduction, waste minimization and many other areas. The ADDS is an integrated system that assists in facility decontamination and decommissioning (D&D) from the planning stages through the waste packaging stages. This system includes three major components:

- Decontamination, Decommissioning & Remediation Optimal Planning System (DDROPS)
- Waste Characterization/Sorting System (WCSS)
- Robotic Waste Packing System (RWPS)

DDROPS is a computer-based planning system that allows a project manager or operator to simulate a facility for remediation preplanning and waste minimization purposes. DDROPS incorporates solid geometric modeling and optimization techniques to help identify locations for segmenting contaminated materials (pipes, tanks, etc.) to improve packaging densities within waste boxes and to minimize radiation exposure to D&D workers. DDROPS can also be used to allow operators to move throughout the virtual facility and familiarize themselves with the surroundings without being exposed to the hazards of the actual facility. Radiation fields, linked to the various objects within the model, aid an operator in estimating radiation doses for operational tasks.

The WCSS provides detailed characterization information on each piece of waste removed during dismantlement operations. It is a standardized characterization platform that can be rapidly modified to accommodate changing waste characterization requirements (e.g., radioactive, material or chemical detection techniques) and different waste stream characteristics (e.g., different types/sizes of waste streams). The characterization information includes weight, volume, radioactive concentrations and type of material. This information is sent to a database that will interface with the robotic packing system and a packaging optimizer.

The RWPS includes a robotic arm system designed for use in a low-profile trailer. This system will optimally segregate and package the waste after it has been sent through the WCSS. The RWPS receives pieces from the WCSS on a conveyor belt, identifies the piece, and calculates the optimal packing location in one of the 4-5 available waste boxes also included in the trailer. It then picks up the piece, moves it to the appropriate container, orients the piece and places it in the correct location in the correct container. When a waste box is filled, a manifest detailing the contents is produced.

The ADDS will assist in improving D&D operation by reducing radiation exposures through preplanning with facility modeling and through robotic waste packaging; by improving waste characterization and ensuring each waste container is adequately manifested; and by minimizing the number of waste containers filled for a given volume of waste.

BACKGROUND/INTRODUCTION

The Department of Energy's (DOE) weapons complex has been transitioning from a production mode into an environmental restoration (ER) mode. As a result of this transformation, the DOE has identified over 7000 contaminated facilities. These facilities are surplus to their needs and must be decommissioned. The cost of remediating these facilities with baseline technologies has been estimated to be in excess of $36 billion. The nuclear utility industry as well as the organizations responsible for university reactors, nuclear laboratories, research reactors, and other laboratory test facilities are faced with similar challenges to those operations by using a variety of baseline techniques, these techniques are labor intensive and extremely costly. D&D liability-holders require new and improved technologies that provide significant cost savings and safety improvements.

INEEL's Advanced D&D System (ADDS) focuses on advanced scientific and engineering principles for improving planning, characterization, disassembly, materials handling, and recycling techniques associated with decontamination and decommissioning (D&D) of contaminated facilities. The ADDS includes a planning tool to simulate the facility being decommissioned and plan the optimal equipment removal which will lead to optimal waste packing. The computer-based planning tool (Decontamination, Decommissioning and Remediation Optimal Planning System - DDROPS) models the facility to be decommissioned. It provides waste volumes and estimated radiation exposures for the preliminary planning process. This tool also optimizes locations for segmenting contaminated materials (i.e. pipes, tanks) and it serves as a tool for the field workers for pre-job planning. As the dismantled material is generated, each piece is delivered to a waste characterization system (Waste Characterization and Sorting System – WCSS). This system will weigh, measure and record all required physical

and radiological properties for each individual piece. The information is then sent to a central database to be stored for future use. The waste pieces are delivered to the robotic packing system (Remote Waste Packaging System - RWPS) via a conveyer belt. This system stages each waste piece and packs the waste pieces in a pre-determined order based on the results obtained from a planning optimizer algorithm. The system will reduce final number of waste boxes,

reduce operator exposure and ensure the waste is fully characterized and manifested for each box.

DECONTAMINATION, DECOMMISSIONING AND REMEDIATION OPTIMAL PLANNING SYSTEM

DDROPS is a computer-based planning system that will allow an operator to simulate a facility for remediation preplanning and waste minimization purposes. DDROPS incorporates solid geometric modeling (Pro/Engineer) and optimization techniques to help identify locations for segmenting contaminated materials (pipes, tanks), to improve packaging densities within waste boxes and to minimize radiation exposure to D&D workers. It also incorporates visualization of radiation fields on the models and can calculate real-time radiation levels/exposure as a function of location or path within the virtual facility.

Input to DDROPS's solid modeler is accomplished in several manners. Existing Computer-aided Design (CAD) files, blueprints, As-Built drawings, photographs, laser-scanning techniques, photogrametry and manual techniques can all be used for initial model generation. Once generated, the model can be used for a variety of tasks. DDROPS has been used to quickly identify existing discrepancies with existing As-Builts versus the facility's current configuration. This comparison can be performed quickly and without exposing personnel to the facility hazards.

The DDROPS 3-D visualization of a facility and its contents has proved useful for familiarizing D&D operators with the facility interiors without exposing them to the hazards, such as radiation fields, associated with the facility (Figure 1). For example, actual radiation levels can be shown within the model and various paths/job activities plotted to determine radiation exposure. This in turn can be used to determine the best pathways and shielding requirements to keep overall worker exposure as low as possible.

By then running a series of algorithms, an operator is able to determine the optimal location for making the necessary cuts to achieve system disassembly. Optimization can be calculated based on a number of operator-controlled constraints, such as waste box dimensions, radiation levels, or mass properties. The constraints may be varied depending on the desired output results, such as:

- minimize the number of cuts,
- minimize the number of waste boxes,
- improve packaging densities, or
- minimize worker radiation exposure, etc.

The INEEL Facilities Deactivation Department conducts the D&D activities at the INEEL. They have already implemented portions of DDROPS into obtaining planning information to aid in safe removal of an underwater reactor by calculating the center of gravity and location to place the lifting rings (Figure 2). A demonstration of DDROPS was also used to calculate the number of waste boxes from an INEEL facility that was recently decommissioned. The facility demolition, completed according to normal practices, resulted in 6 waste boxes. The DDROPS

estimate was 2 boxes if the D&D had been completed with optimal cutting – three times less waste based on volume.

The results of this technology demonstration proved successful at showing several advantages as compared to baseline techniques:

- D&D planning to reduce risk of radiation exposure to workers.
- Disassembly planning to minimize waste volumes and disposal costs.

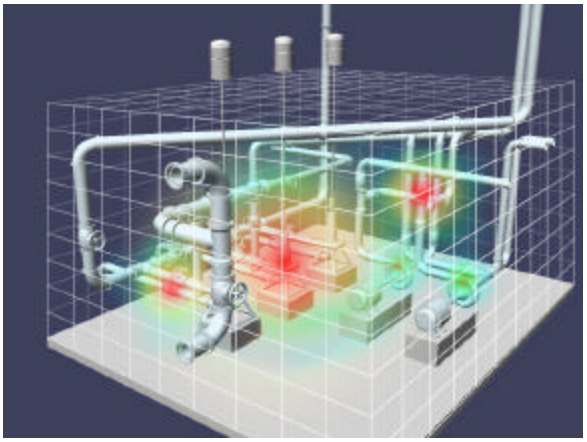

Fig. 1. DDROPS model visualization of radiation fields.

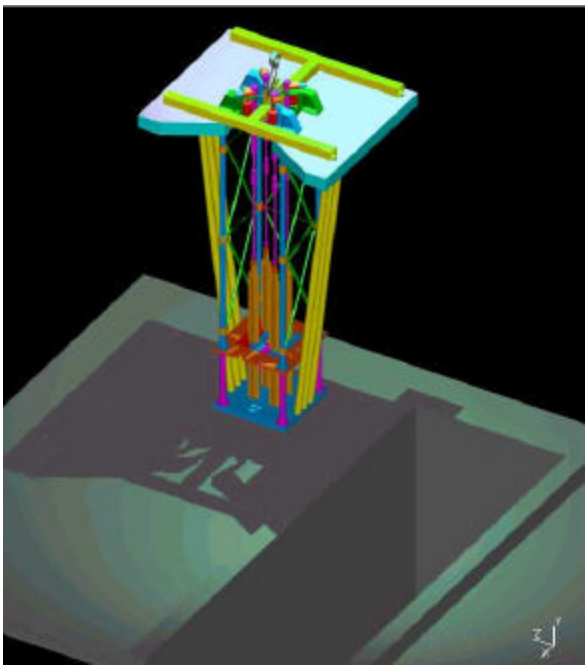

Fig. 2. INEEL ARMF reactor was modeled to determine lifting procedures

- Comparisons of As-Built drawings to latest blue prints.
- Calculate mass and geometric properties to compare with shipping constraints to minimize shipping costs.
- Interactive/visual file of facilities for historic reservation purpose.

WASTE CHARACTERIZATION AND SORTING SYSTEM

The WCSS is a standardized platform for determining the physical and radiological characteristics of a waste item (Figure 3). It is a computerized data acquisition, scanning, quantitative assay and data analysis system that can be rapidly modified to perform assay functions for a broad range of applications and configurations. As such it will support material identification/characterization, sorting/recycling during the disassembly process as well as accurate waste container manifesting.

The system is flexible, allowing it to be modified to meet a number of assay requirements including those for radioactive and hazardous waste. The WCSS performs self-calibration, scanning (weight, volume, radiological isotopes, metal type), quantitative analysis, background

Fig. 3. A prototype of the WCSS has been demonstrated at the INEEL.

check and reporting functions. The system includes a number of self-test functions that will notify the operator if the system is not operating correctly or if the item being processed is outside the waste characteristics appropriate for characterization or disposal. It utilizes a computer controlled scanning bed and laser and weighing system to determine the gamma ray detection efficiency for materials as they are being passed through the system. The system is completely automated without technical support in either the data acquisition or analysis portions. This minimizes the potential for operator error and changes in the system. In addition, the system is integrated to allow complete recovery of all measurement and other data used for the characterization of the waste.

The main WCSS advantages are that it provides a quantitative assay technology that can be reproduced and operated without significant technical support. Further, it can be rapidly modified to meet a range of assay applications. It can be used to show regulatory agencies quantitative reproducible assay data that can be used to make waste disposal decisions based on the radioactive material content of the waste. Further, since little technical support is required, the system can be reproduced many times and licensed for use at numerous sites, which provides cost savings for operators and in meeting regulatory requirements.

ROBOTIC WASTE PACKING SYSTEM

The RWPS is a robotic system used to optimally segregate and package the waste after it has been sent through the WCSS. The RWPS is capable of receiving pieces from the WCSS, identifying the piece, calculating an optimal packing location, picking up the piece, moving it to the appropriate waste container, orientating the piece and then placing the piece in the waste container. The RWPS is designed to fit in a mobile trailer or a series of trailers that can be easily moved to a decommissioning site (Figure 4).

This system uses a remote object recognition system to identify the piece geometry and determine the center of gravity using the information available from the WCSS. It will then pick up the piece and place it in the appropriate staging area then automatically retrieve the pieces from the staged area and optimally place them into the waste container as detailed by the optimal packing algorithm. It will also update a central database with the actual location of the item. This system's design allows it to be housed within a self-contained mobile semi-trailer.

The RWPS research team is coordinating with another INEEL robotics project and has utilized their base material handling design to prove out that aspect of the RWPS. Enhancements in the

areas of gripper, three joint arms, and low-profile z-mast have also been completed. The vision system will use depth, color, and edge detection to discriminate overlapping/adjacent objects specified by an operator. A real-time packaging algorithm, based on information generated from the WCSS and seen with the vision system is also currently being developed.

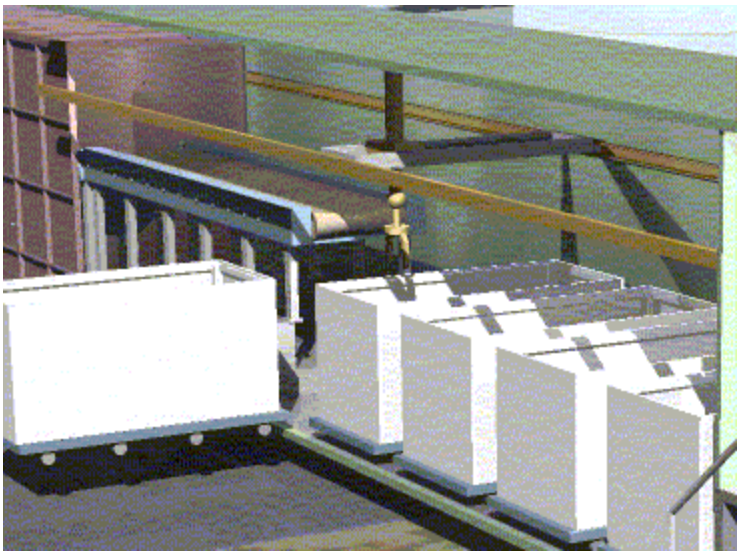

Fig. 4. The RWPS will remotely optimize waste packing in containers.

The potential benefits of the RWPS include:

- reduction of personnel radiation exposure through robotic waste packaging
- integration with the waste characterization system to accurately manifest waste containers
- minimization of number of waste containers required for a given volume of waste

SUMMARY

The ADDS is an integrated system that assists in facility D&D from the planning stages through the waste packaging stages. This system includes three major components: a preplanning system (DDROPS); a waste characterization system (WCSS) and a robotic packing system (RWPS).

The technology has several advantages including:

- Reduces risk of radiation exposure to workers.
- Minimizes waste volumes and disposal costs.
- Compares As-Built drawings to latest blue prints.
- Calculates mass and geometric properties to compare with shipping constraints to minimize shipping costs.
- Provides interactive/visual file of facilities for historic preservation purpose.
- Provides a quantitative assay technology that can be reproduced and operated without significant technical support.
- Accurately manifests waste containers.