

## ADVANCED TECHNOLOGIES FOR D&D OF THE A-1 NPP

Vladimír Míchal, Miroslav Baca, Kamil Kravárik, Peter Menyhardt

VÚJE Trnava, Inc. – Engineering, Design and Research Organization

Department for Preparation of NPP Decommissioning

Okružná 5, 918 64 Trnava, Slovak Republic

Phone: +421 805 5992016, fax: +421 805 5992024

vmichal@vuje.sk, baca@vuje.sk, kravarik@vuje.sk, menyhardt@vuje.sk

### ABSTRACT

Using of advanced technologies is necessary for successful performance of the A-1 NPP Decommissioning Project. Very important is using of advanced computer aided (CA) technologies as well as remote handling manipulators and robots. The current status and results of using of 3D laser scanner SOISIC, software 3Dipsos, software EUCLID for 3D modeling of as-build building construction and technology of A-1 NPP is presented in paper. The main goals and the obtained results of the A-1 NPP Decommissioning Project are also shortly described.

The A-1 NPP Decommissioning Project is the most important project of NPP decommissioning in Central Europe. The presence of radioactive, toxic or hazardous materials limit personnel access to facilities and therefore it is necessary to use advanced CA and remote technologies for decontamination and dismantling. The main goal of the project is to achieve radiologically safe status of the NPP. The project should give the complex solution of problems related to D&D of NPPs in Slovakia. Verified methodology and technology should be used as a generic approach for decommissioning of the V-1 NPP and V-2 NPP in Jaslovské Bohunice and Mochovce NPP as well as the other European NPPs with WWER reactors. The advanced technologies should significantly contribute to safe and low cost decontamination and dismantling of the A-1 NPP Jaslovské Bohunice as well as other NPPs. Substantial reduction of occupational doses and environmental impact is also expected.

### INTRODUCTION

Nowadays there are 6 units in operation in the Slovak Republic (1<sup>st</sup> and 2<sup>nd</sup> unit of V-1 NPP, 1<sup>st</sup> and 2<sup>nd</sup> unit of V-2 NPP and 1<sup>st</sup> and 2<sup>nd</sup> unit of Mochovce NPP), 2 units are under temporarily stopped construction (3<sup>rd</sup> and 4<sup>th</sup> unit of Mochovce NPP). All mentioned reactors are of Russian design WWER-440, type V-230 and V-213. One unit of the A-1 NPP (reactor cooled by CO<sub>2</sub> and moderated by heavy water) is in the process of decommissioning.

Nuclear power plant A-1 was in operation from 1972 to 1977 and was finally shutdown after two accidents (level 4 according to the International Nuclear Event Scale). Reactor unit of the A-1 NPP is in the preparation stage for decommissioning of their components. Some auxiliary buildings have already been decommissioned to the green field. A part of turbine building is used for processing and storage of radioactive waste. All spent fuel from the A-1 NPP was transported to Russia. Liquid radioactive waste except water of the spent fuel pool was

processed and some intermediate radioactive waste from the main production unit was partially treated. For future successful realization of the A-1 NPP D&D is very important that Radioactive Waste Treatment Center at Jaslovské Bohunice site and also Final Repository of Radioactive Waste at Mochovce site are already in operation.

Nuclear Power Plants Research Institute has been chosen as a main cooperator for the A-1 NPP Decommissioning Project, which is the most important project of decommissioning of NPP in Central Europe. The main goal of the project is to obtain radiologically safe status. It include following activities:

- conditioning disposal storage of liquid radioactive waste, solid and metallic radioactive waste, sludge and sorbents,
- decontamination of specified equipment structures to reduce free activity,
- construction of store rooms for waste.

The project should give the complex solution of problems related to NPP decommissioning mainly in Slovakia but also for other European NPPs with WWER reactors.

## **USING OF ADVANCED CA TECHNOLOGIES IN D&D**

Decommissioning of NPP includes physical and radiological characterization, decontamination, dismantling and demolition, waste and spent fuel management. In many tasks it is necessary to undertake significant research effort and use of advanced technologies (1).

Knowledge of physical configuration, contaminant levels within facilities is required for work planing, ALARA planning, cost estimating, and worker training for safe decontamination and dismantling. In many cases, as-build drawings do not exist and contaminant data is limited. Manual characterization is difficult, costly and time consuming and therefore it is necessary to build a 3D model and attributes database of facilities.

D&D technological tools can be divided into two main groups:

- equipment for performance of D&D (remote handling manipulators, robots, treatment facility etc.),
- tools for engineering activities and support of D&D (digitalization of documentation, the real state verification, 3D scanning of construction part and equipment, computer simulation of work procedures performed in high radiation environment, modeling of NPP equipment etc.).

In our Nuclear Power Plants Research Institute following HW and SW are used for the A-1 NPP Decommissioning Project:

- Silicon Graphics workstations, 3D scanner SOISIC, 2D scanner and A0 plotter,
- database system ORACLE 8i, CAD system EUCLID, SW Megavision, 3Dipsos.

3D SOISIC scanner and software 3Dipsos are used for acquiring of real state of civil constructions and equipment within the A-1 NPP. EUCLID is used for 3D modeling of facilities and remotely operated robotic

systems. In addition it is used for 3D simulation of operations of robots during decontamination and dismantling. However, application of the IGRIP (Interactive Graphics Robot Instruction Program) from DELMIA Corporation (formerly DENEBO Robotics, Inc.) is planned to cover all necessary aspects in development, programming, analyzing and simulating of robotic systems for D&D.

Achieved results and experiences with digitalization of documentation, 3D scanning of non and low radioactive construction part and equipment shows that their very effective use for performance of D&D activity is possible. Database application for the A-1 D&D in ORACLE 8i is also developed. The main goal of the A-1 NPP database is to serve as a source of verified data for calculation of various D&D parameters (costs, duration, personnel dose, amount of various kinds of materials etc.). Above-mentioned calculations will be done by special calculation application, which is also developed in Slovakia.

3D laser scanner SOISIC is used for a three-dimensional digitalization of a real scene. The SOISIC range sensor uses a low-power beam, which is deflected by a scanning mirror to sweep across a given scene. The diffused light from objects present within the field-of-view is detected by a CCD camera. XYZ coordinates indicating the laser beam's impact point with an object surface are computed by triangulation at a rate of 100 discrete points/second. The field-of-view and spatial sampling rate can be set by the operator prior to starting the acquisitions.

At least two clouds of points from the two points of view represent output from the 3D scanning. The Consultation, Modeling and Consolidation modules in 3Dipsos (Interpretation of Points in the form of Semantic Objects) software program are consequently used for the reconstruction of the CAD entities closest to the 3D points and modeling of 3D models of mid-range and large objects. 3Dipsos software is running on SGI workstations. Generally, two main steps can be distinguished within this phase of modeling – information acquisition and reconstruction. Reconstruction is mainly done by 3Dipsos software and is carried out as accurately as possible to the acquired points in order to be as real as possible (5). The final 3D model can be exported to different existing CAD application packages.

It should be noted that 3D scanning and modeling are relatively laborious and time consumption process. This approach should be used in case where manual characterization is difficult or impossible mainly due to very bad radiation situation. The range of rates of duration for scanning and for modeling is approximately from 1:6 to 1:8, but the more experience and skills is obtained the less time is need for modeling. Our experience and practice show that 3D scanner SOISIC could be used not only for scanning of technological equipment, but also for scanning of civil engineering parts of NPP, upper part of underground tanks etc.

Figure 1 shows example of acquired cloud of points and 3D model of equipment, which was created in this initial phase of the A-1 NPP Decommissioning Project.

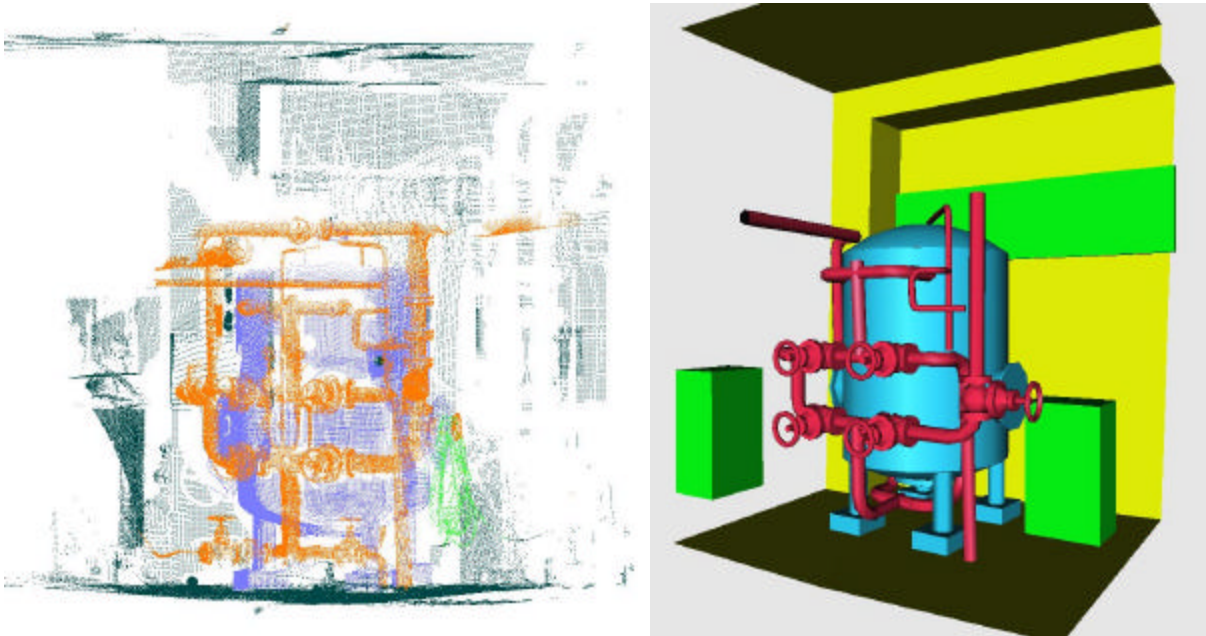


Fig. 1. Acquired clouds of points and 3D model of equipment (3D laser scanner SOISIC, SW 3Dipsos).

## USING OF REMOTELY OPERATED MANIPULATORS AND ROBOTS IN D&D

The presence of radioactive, toxic or hazardous materials limits personnel access to facilities and therefore it is necessary to use remotely operated manipulators and robots for decontamination and dismantling of NPPs facilities. Their use also contributes to substantial reduction of occupational doses (2, 3, 4). In our Nuclear Power Plants Research Institute we have developed general-purpose manipulators as well as manipulators for special tasks.

MT-15 is a mobile remotely control manipulator, which was developed for inspection tasks and removing damages in the nuclear facilities after accident. It is modular system, which can be equipped with analyse or decontamination unit. MT-15 consists from remote vehicle, which is bearing manipulator and working unit.

General-purpose manipulator MT-80 was developed for decontamination and dismantling tasks. MT-80 is hydraulic arm with 5 degree of freedom and 1.8 m reach. It is made of special titan-dural alloy and payload of manipulator is 80 kg. The miniature hydraulic actuators are used for actuating. Control unit allows to program laborious repeated tasks, which are often used in decontamination or dismantling. The wrist of the manipulator can be equipped with necessary decontamination tools. Technical details and application of manipulator in D&D are presented in Fig. 2 and Fig. 3.

One of the main priorities in the A-1 NPP Decommissioning Project is decontamination and decommissioning of underground storage tanks. For that purpose was developed special manipulator DENAR-41. It is long-reach hydraulic arm with vertical bearing structure, which is placed over the storage tank. The main difficulties in the development of DENAR-41 were large diameter of the storage tanks ( $\varnothing$  16 m) and small dimension of the hole

in inspection chamber (540 x 540 mm). Two cameras are planned for in-tank views of the DENAR-41 operation and one of them is mounted to forearm to watch operation of the decontamination head. DENAR-41 can also hold and maneuver MT-80 or tools that may be required to assist in waste retrieval. At the time of this paper submittal, design and manufacture of manipulator is in final stage. Initial mockup testing is planned at the beginning 2001.

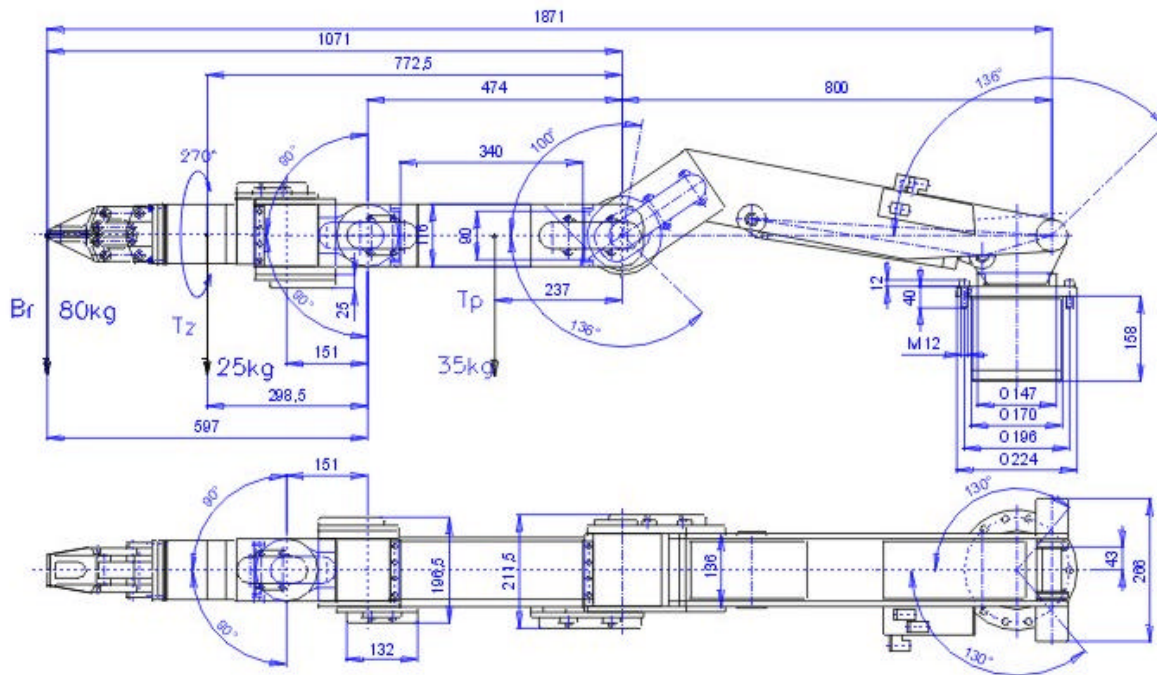


Fig. 2. Configuration and dimensions of general-purpose robot MT-80.

Great effort is also paid to development of decontamination and dismantling head for mentioned manipulators. Some of those tools are very unique, because they are dedicated for special tasks.

As part of its research and development activities for decommissioning nuclear facilities the Nuclear Power Plants Research Institute has undertaken the decontamination and dismantling modeling program. The data, which are acquired by 3D SOISIC scanner and processed by software 3Dipsos and EUCLID are used for simulation of tasks performed by robots. These procedure helps to optimize their movements and thus assist the operator in situ perform D&D tasks. It also contributes to reduction of occupational doses and avoiding collision of manipulators with equipment of NPPs facilities. Fig. 3 shows example of dismantling of pipe equipment in underground tank by MT-80 and DENAR-41.

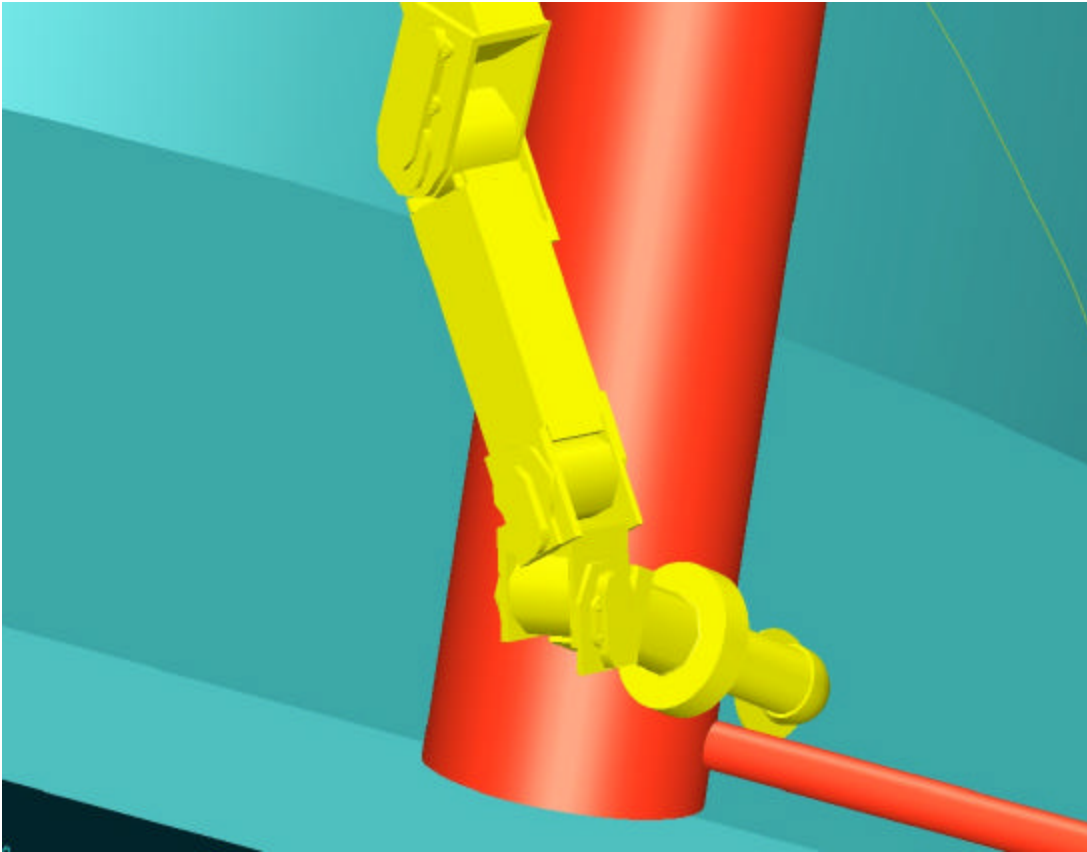


Fig. 3 Simulation of dismantling task of MT-80 in underground tanks.

## CONCLUSION

D&D of nuclear installation is challenging work from many points of views and one of them is necessity of using advanced technologies. The software, hardware and remotely operated robots, which is employed, should magnificently contribute to safe and low cost decontamination, dismantling and decommissioning of NPP A-1 Jaslovské Bohunice as well as the other NPPs. Substantial reduction of occupational doses and environmental impact can be also expected.

The trends in the Slovak Republic in the field of D&D are compatible with world trends. Slovak Republic co-operates with such international organizations like European Union, United Nations, IAEA, OECD and also with Germany, France, Great Britain, USA, Japan, Russian Federation, Hungary, Poland and Czech Republic. Intensive international co-operation at all levels is being developed at the present time.

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