AN APPLICATION OF A STATE OF THE ART 3D-CAD-MODELING AND SIMULATION SYSTEM FOR THE DECOMMISSIONING OF NUCLEAR CAPITAL EQUIPMENT IN RESPECT OF GERMAN PROTOTYPE SPENT FUEL REPROCESSING PLANT KARLSRUHE

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ABSTRACT

Siempelkamp Nukleartechnik GmbH is engaged in the optimization of decommissioning processes for several years. With respect of the complexity of the projects, the time frame and the budget it is necessary to find more effective ways to handle those tasks in the near future.

Seen from this angle, the decommissioning of the German Prototype Spent Fuel Reprocessing Plant Karlsruhe (WAK, Fig. 1) is an excellent example for the use of state of the art 3D-CAD- modeling and simulation systems to reach those facts.

The situation: During 25 years of operation, 208 tons of nuclear fuel with a burnup of up to 40 GWd/t including MOX-fuel, have been reprocessed in this plant.

Fig. 1 Aerial view of the WAK Karlsruhe

The decommissioning and dismantling will be achieved in six steps taking into account that some processing equipment can be dismantled before and the rest only after the High Active Liquid Waste Concentrate (HAWC) has been vitrified approximately by mid of 2005.
After the successful beginning of the remote dismantling of the main process cells from March 2000 /1/, the next remote dismantling project at the WAK was initiated April 2000 (Remote Dismantling of the WAK High Active Waste Concentrate Storage Facilities /3/).

Five Medium Active Waste (MAW) storage tanks and four High Active Waste Concentrate (HAWC) storage tanks, located above ground in five heavy shielded cells adjacent to the main process building, have to be dismantled. In total ~ 130 tons of concrete (from access openings) and ~ 120 tons of metal structures covering an overall activity of ~ 2,5 x E15 Bq have to be dismantled remotely with respect to radiation levels up to 2200 mSv/h.

In the past, WAK used and operated mock-ups (Scale 1:1) to verify planning, design and operation aspects with remote dismantling technologies:

- Horizontal remote dismantling of two vessel off-gas cells /4/.
- Vertical remote dismantling of four process cells /1, 2/.

Due to the fact that the experiences of the WAK in past projects will consequently continue, and to reduce costs and safe time, the new project "Horizontal Remote Dismantling of the WAK Waste Storage Tanks" will be verified by state of the art 3D-CAD tools, except for single hardware integration tests, staff training and cold commissioning of the remote dismantling equipment /3/.

INTRODUCTION

For coverage of this task WAK chose for this step the know how of the Siempelkamp Nukleartechnik GmbH with its experience in CAE and planning of

- components an systems for decommissioning and dismantling
- equipments for nuclear waste treatment
- upgrading of technical installations and systems (concepts, licensing procedures, detail engineering, construction, manufacturing, commissioning)
- construction of remote-controlled dismantling equipment and auxiliary utilities

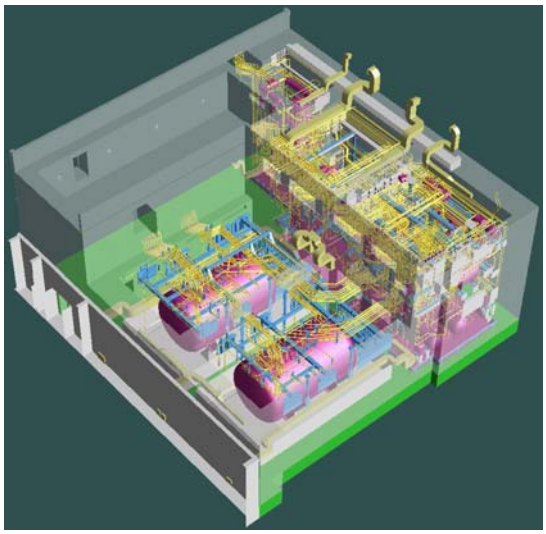

Fig. 2 LAVA-building, HAWC storage tanks

The five MAW storage tanks and the four HAWC storage tanks are situated near by the main process building in two separate buildings

- Building HWL :
  five MAW- and two HAWC storage tanks
- Building LAVA:
  two HAWC storage tanks (Fig. 2)

The tanks are located in heavily shielded cells above ground with no access possibilities for dismantling (openings, cell hatches e.g.) and no radiation and contamination control infrastructures for environment and staff (airlocks, additional shielding, auxiliary buildings e.g.).

In order of the remaining activity and radioactivity (13 mSv/h - 2200 mSv/h) at the nine waste tank cells, a technical concept for the remote dismantling of the MAW-/HAWC tanks has been worked out /3/ to meet the main WAK radiation protection criteria: manual dismantling is only possible at a radiation level < 0,5 mSv/h.

The customers objective was defined as follows:

- Conceptual design of remote dismantling equipment and auxiliary utilities
- Development of remote access and dismantling strategies
- Detail planning of remote dismantling tasks (time schedule operation manuals etc.)
- Detail engineering of hardware equipment
- Verifications and simulation of maintenance and salvage operation
- Licensing
- Simulation of remote dismantling tasks to substitute hardware Mock-Ups
- Staff training

THE PRACTICAL APPLICATION OF 3D-MODELING AND SIMULATION

The Requirements

In October 2001 Siempelkamp Nukleartechnik GmbH, Krefeld, Germany, was ordered by FZK for the 3D-CAD-modeling and simulation of the remote dismantling of the WAK medium and high active waste tanks

The practical application should meet the following criteria:

- State of the art
- Widely compatible to common CAD-Tools of the customer, such as AutoCAD, MicroStation and so on
- Applicable on Windows NT 4.0
- Quick perception of information from complex circumstances
- Arbitrary spatial illustration from complex circumstances, witch are not easy to see in reality
- Largely automatic detection of interface problems
- Automatic generation of drawing-sets without contradiction
- Possibility of "walk through" in the plant for yielding information about arrangements, in parts witch are not accessible
- 3D-presentation of decommissioning measurements
- Automatic detection and dynamic control of interface problems and collisions
- Spatial simulation of important decommissioning steps

Modeling of the Infrastructures

The generation of 3D-Model was carried out by using PDMS – "Plant Design and Management System" designed by CADCENTRE. The system, already used by Siempelkamp engineering department for planning and visualization, meet the criteria best after investigation of the market for such kind of software's. PDMS, which has been developed especially for industrial process design, gave a number of additional advantages. Those are:

- Construction environments for typical equipment
- Storage of equipment data records in a data base, which allows classification of related additional information (e.g. activity concentration, radiation intensity)
- Concurrent engineering (multiple user environment)
- Possibility of programming of recurring tasks and adaptation of the user environment

Complementing on another was used the CADCENTRE - "Review Reality"-Tool to create three dimensional images and digital videos of single courses of events.

In this way, the layout drawings of relevant existing WAK infrastructure were in 2000 completely transferred into the system ("as build"-documentation, Fig. 3). Additionally, the conception layout of the proposed new remote access utility building "HWL Annex South" including its infrastructure (cranes, shielding - doors and shielding - windows, waste handling equipment etc.) was planned and developed with assistance of the 3D-digital-tools as well. This way did provide a high flexibility in cases of alteration of design, a better integration in existing structures, the optimization of transport distances and others.

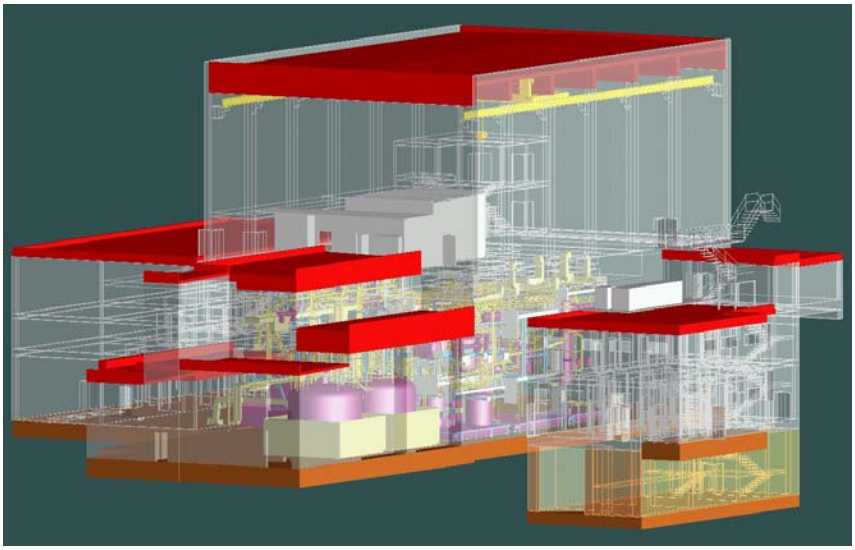

Fig. 3 3D-Model of previously existing structures and equipment

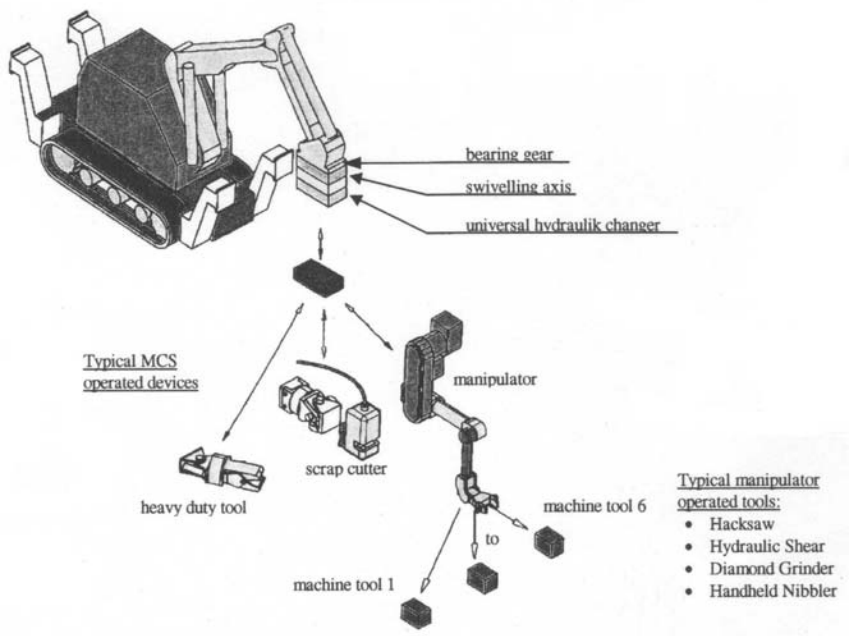

Fig. 4. Typical subassemblies of the MCS / 3 / as an example for used remote equipment.

Modeling of the Remote Controlled Equipment

To create the conditions for simulation, the second modeling task is the remote controlled equipment (Fig. 4):

- A manipulator carrier system (MCS)
- Several power manipulators
- Typical manipulator operated tools

Those equipment is the variable in the model witch is qualified due to the results of dynamic simulation. This is the immense advantage and saves costs as well. It allows the improvement of the tools gradually in the model before the practical realization.

Simulation of Remote Dismantling Tasks

The simulation of remote dismantling tasks is an interactive way to use data won from the model in interaction with additional tools and the dynamic simulation itself.

***First step**:* By support through the PDMS-model with its additional data (see 2.2), for instance the activity potential in the dismantling area as a prior criteria for the demolition order can be illustrated. For this, the geometric information of the equipment, measuring points and the spatial real estate are used. The

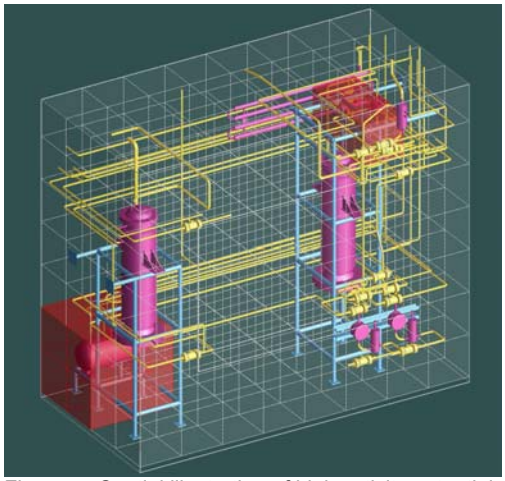

Fig. 5 Spatial illustration of high activity potentials (red boxes) as a prior criteria for the demolition order in a typical WAK cell

calculation of nuclide vectors and ascertaining of spatial dose is estimated with "MicroShield"-software. The data exchange is carried out by the use of a self programmed ASCII-interface. By this way, other actual facts can be shown as well (e.g. examining interface problems due to designs hired from different companies, checking the state of fitting between old and new lifting systems or the manipulator carrier system,…).

***Second step**:* After achieving of preconditions, the dynamic simulation is used to verify demolition strategy. This already is and will be done with the software application "MSC.visualNastran". It provides the opportunity for real time dynamic simulation processes and combines advanced motion simulation and stress analysis technology with sophisticated authoring and presentation capabilities. Because there is no direct software application interface between the 3D-body related data of PDMS and the surface related data sets of "MSC.visualNastran" it had to be developed a own solution. By the roundabout way of the mentioned interface, the entire model including all beforehand described equipments are transferred to the simulation tool.

In this way, the following tasks partly are and will be completed until September 2002 to substitute Mockup's:

- Testing of the designed manipulator carrier system its manipulator and its tools for single demolition steps
  - Positioning of accessory equipment and peripheral technical facilities
  - Optimization of remote equipment
  - Development of slash sequences
- Simulation of remote dismantling tasks
  - Demolition tasks
  - Maintenance processes
  - Supporting of licensing procedures
- Simulation of removal of malfunction
  - Salvage operations
  - Remote restoration measures
- Visualization of dismantling steps at special state
  - Locking procedures
  - Wrapping processes
- Finding of ideal camera positions
- Development of the operation manual
- Staff training

By this means, there are recognized problem areas right from the beginning without spending a lot of hardware engineering, what stands for money finally.

CONCLUSION

Using modern design and simulation tools gives a high reliability, interface problems will be minimized and in fact:

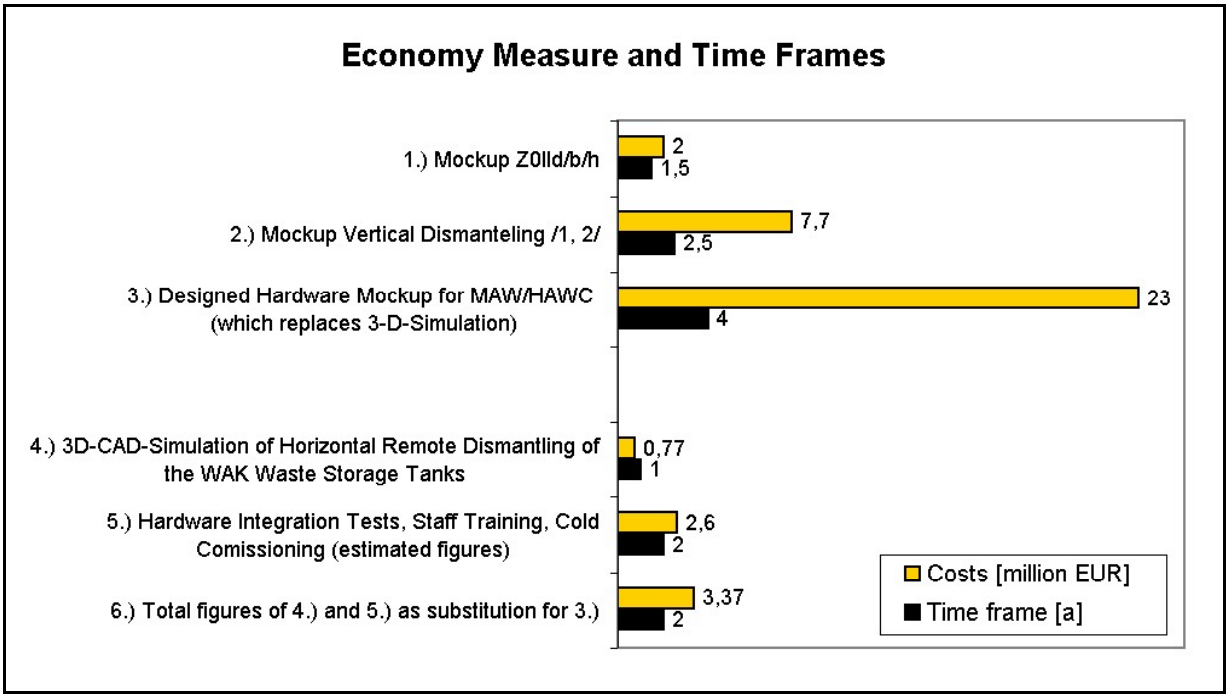

Fig. 6 Cost and time comparison of several WAK remote dismantling projects

At the current state of the WAK project, it can be already shown that the use of 3D-modeling and simulation will safe time and money. Figure 6 shows the economy measure as well as time frames of design verification with 100 % Mockup (3.) in comparison to 3D-Simulation and single hardware integration tests (6.).

Of course, it is not possible to test everything with 3D-modeling and simulation without practical tests, especially in the field of decommissioning of nuclear capital equipment. Depending on the special situation, you always have to concentrate on the practical experience of the operator to acquire the necessary knowledge for the special task.

In the end, the experience of the WAK engineers together with the know how of Siempelkamp Nuklertechnik GmbH shows a successful way to handle the challenge.

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