

Preliminary Design of Heavy Water Research Reactor Decommissioning Engineering Technology Supporting System

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1.1 Background

Heavy Water Research Reactor (HWRR) is the first reactor in China, after 49 years safe operation, which also will be the first decommissioning reactor in China.

The decommissioning of HWRR is comprehensive, which include dismantling, decontamination, waste management, radiation protection and so forth. There will be a lot of difficulties in our engineering work.

How to analyze and evaluate the feasibility of project is important for our decommissioning works.



1.1 Background

Physical mock-up test is an important way, but whose using is limited by high costs and spatial conditions.

As the development of computer graphics, more and more simulation technologies has been used in all kinds of engineering projects including decommissioning work. A virtual mock-up system is more effective and efficient than the physical one.

So, according to HWRR decommissioning requirements, we are going to build an engineering technology supporting system for analysis and evaluation of our decommissioning project.





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2.1 HWRR

- The first reactor in China
- Construction in May 1956
- First criticality on June 13th 1958
- Coolant and moderator: heavy water
- Reflector: graphite
- With the core of water tank structure
- Initial enhanced power: 10 MW
- Outage and upgrading during 1979-1983
- Modified enhanced power: 15 MW
- Permanently shut down in 2007







2.1 HWRR



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HWRR Decommissioning





2.2 Decommissioning Plan

Three stages for nine years.

Stage 1: preparation and decommissioning of peripheral systems,

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scientific researches and test verification for key technology;

Stage 2: decommissioning of systems in the basement, including primary coolant system, secondary coolant system, helium system, hot cells and so forth;

Stage 3: decommissioning of reactor block and supporting systems; Finally, the reactor building is going to be modified as a historical museum.





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Objective of any decommissioning projects :

- improvement of engineering accuracy and safety
- shortening the time
- reduction of costs
- optimization of protection and safety
- minimization of radioactive waste



Problems in our designing and performing :

- decommissioning plan is often in the 2D drawing
- working environment and process is unfamiliar for constructor
- project need to be analysis and evaluate repeatedly
- availability of dismantling equipment is hard to test
- evaluation of space dose rate is inaccurate



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Build the 3D model :







What we need to simulate :

- dismantling of reactor internals
- construction technology process
- radioactive dose
- ➢ costs
- personnel
- progress
- waste volume









Functional framework :





General Immersive Simulation Platform



The traditional Immersive Simulation Platform is basic on virtual reality engine, which can't read the CAD/CAE data from simulation software directly. The virtual reality interface is necessary for this kind of platform.



Immersive Decommissioning Simulation Platform



But for the improvement of process designing and the building of immersive, interactive and imaginative environment, our decommissioning simulation platform combines simulation software and virtual reality engine together, making our designer can work in the virtual reality environment.



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Hardware & software architecture :





Key technology :

- Reactor internals dismantling simulation
- Decommissioning project evaluation and management





Reactor internals dismantling simulation



Engineering scientific research test verification for reactor internals demolition is going to be performed in the first stage. A lot of difficulties will be faced such as the cutting of inner vessel and outer vessel, the removal of graphite and lead, the collection of sands and so on. We are to simulate the dismantling process by our system.





There are two important equipments will be used for dismantling of reactor internals: manipulator and robot. Building kinematic and dynamic model, and then by the means of simulating the actions of cutting, grabbing and transportation, to evaluate the dismantling time, sequence, accessibility and so on.



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In order to make the simulation more real and effective, we are going to use some physics engine and cutting methodology on it. Besides, we will do some researches and development on mathematical algorithms and operations research to achieve the optimal solution of the dismantling process.



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Decommissioning project evaluation and management



For dismantling simulation, accuracy and reality of the solution is the key point. But for the project evaluation and management system, comprehensive factors are more important. This function will be used to manage and evaluate the decommissioning of all the reactor systems





Decommissioning project evaluation and management

In our system, 3D model is a digital representation of physical and functional characteristics of the facility, which is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its decommissioning life-time.

- From design phase to construction phase
- Including designing and performing of dismantling, decontamination, transportation, temporary storage and so on.
- Evaluation and management of personnel, costs, waste volume, radioactive dose and so forth
- By the mean of Product Data Management, Product Lifecycle Management and other management ways, to achieve the objective.







Conclusion

As the first reactor in China, Heavy Water Research Reactor is under the preparation for decommissioning state. Its decommissioning is a comprehensive task, in order to improve the evaluation of the feasibility and management of the process, we are going to build an engineering technology supporting system by using the technology of computer simulation, virtual-reality, visualization and database.

Our decommissioning technology as well as decommissioning simulation technology are still in the early stage. So, we are faithfully looking forward to having the opportunity to learn and cooperate with you.







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