REMOTELY-OPERATED DISMANTLING OF THE REACTOR INTERNALS AT NIEDERAICHBACH POWER PLANT USING MANIPULATORS

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ABSTRACT

The joint venture NOELL/NIS received the order for the project and planning work and execution of the dismantling of the nuclear power plant Niederaichbach from the Kernforschungszentrum Karlsruhe.

According to the present situation of the work progress a green meadow planted with green bushes shall be created in about 4 years instead of the present nuclear power plant.

The dismantling and the disposal of radioactive internals in the reactor are hereby the technically most sophisticated and most difficult activities. Target is to prove by this work that it is possible according to the present level of engineering to perform the disposal of a nuclear reactor without danger. This can improve to successfully obtain the political acceptance for future nuclear engineering projects.

1. BACKGROUND INFORMATION ABOUT THE NIEDERAICHBACH POWER PLANT

At times, when enrichment of uranium was still difficult, research activities were looking for a possibility to operate a nuclear reactor with natural uranium. After the completion of the NPP Niederaichbach there was sufficiant enriched uranium for acceptable prices on the world market - the concept of the NPP Niederaichbach had been superseded by the development.
Difficulties during the commissioning of the reactor in the heat exchanger area caused the shut-down of the plant after only 18 days of operation at full load.

Data of Work:

Start of construction work	1966
First criticality	December 1972
Reconstruction work/ Commissioning tests	1972 - 1974
Shutdown	July 1972 - 1974
Decision for decommissioning	December 1974
Approval for "safe enclosure"	1975
Contract for complete demolition given to NOELL/NIS	1979
"Safe enclosure"	1981
Start of dismantling	1987
Remotely handled dismantling	1990
"Green meadow" condition	1994

After shut down of this nuclear power plant the technical problems of disposal were to be studied. Because of its relatively low activity inventory the nuclear power plant of Niederaichbach provided a good example for this type of work.

2. LAYOUT OF THE REACTOR

The construction of this heavy-water reactor type is very complicated and consequently makes great demands upon the remote-operated dismantling. The assembly is composed of a great number of welded and bolted connections with different wall thicknesses. Mainly stainless steel, ferritic steel and zirconium alloy were used as fabrication material. (see Figure 1)

Technical Data:

Gas-cooled pressure tube prototype reactor

Moderator	Heavy-water D_2O
Cooling agent	Carbondioxide gas CO_2
Thermic capacity	320,6 MW
Electric net capacity	100,4 MW
Moderator tank	
nominal diameter	6.140 mm
height	5.240 mm

The masses of the reactor components to be dismantled by remote handling are composed of the following equipment:

Component	Weight (tons)	Material
Moderator tank	32	Austenite
Pressure tubes	21	Special material
Pressure tube shafts	35	Ferrite
Seals and plugs	49	Austenite/ferrite
Neutron shields	218	Austenite
Thermic shield	137	Ferrite
Total mass	492	

3. PREPARATORY MEASURES FOR REMOTELY OPERATED DISMANTLING

The following requirements were asked for the remote-operated dismantling:

- No extension of the existing control area for work of dismantling, crushing and conditioning.
- Dismounting of the activated internals within the biological shield without water shielding, since filling of the reactor systems with water would have been connected with a considerable work and considerably additional secondary waste.
- Dismounting of contaminated and activated components and facilities as far as possible by mechanical separation processes.

With the aid of the available drawings and descriptions of construction a strategy was developed as basis for the dismantling. The internals were investigated for possible techniques of crushing and subsequently the necessary toolings and machines were developed. An infrostructure conforming to the requirements had to be provided, such as access and departure systems, energy systems, control area (protection against radiation), lavatory and other facilities.

4. WORK STAGES AND THEIR SEQUENCE

The strict compliance with the stipulated work stages is necessary by all means in order to achieve a safe dismantling.

The work stages were stipulated according to the following criteria:

- Safety of activity
- Low load of radiation
- Optimal use of toolings

The sequence of work stages was stipulated in such a manner that the separated work piece can be removed without difficulties and that the secondary waste does not cause disturbances for the following work stages.
(see Figure 2)

5. REQUIREMENTS OF THE EQUIPMENT

The toolings have to be taken by a remote-operated manipulator and the work stage has to be performed by this manipulator. A redundant securing has to be provided against possible false operations. The reactor internals have to be crushed to such a size that they can be deposited in an optimum manner into the standardized containers. Due to the high costs of ultimate storage a high packing density is emphasized, i.e. the number of required containers must be as small as possible.

The equipment has to comply with the following criteria:

- Low secondary waste
  Small quantity of cooling fluid, small quantity of dust involved.
- Sturdyness
- Redundantly designed equipment performing work of other machines in case of their failure.

6. DESIGN AND TESTING OF THE MANIPULATORS AND TOOLS FOR THE VARIOUS TASKS

Three manipulators are provided for the remote-handled dismantling of the reactor internals. (See Figure 3)

Rotary manipulator

The rotary manipulator is a five-axis robot with the following possibilities of movement:

1.	Circular rotation	≥ 360
2.	Horizontal moving	3.3 m
3.	Vertical moving	15 m
4.	Rotation of mast	≥ 63
5.	Opening and closing of the gripper	

The special design of the manipulator makes it possible to move across the cylindrical spaces underneath and above the point of support. The length of mast is adapted to the various stages of dismantling.

The rotary manipulator is designed for the duty of separating all detachable and undetachable connections inside of the reactor and to transport these parts into the crushing station.

Ring saw

The ring saw is actually an abrasive and cutting-off machine which is only required for crushing of the thermic shield.

Crane manipulator

The reactor internals can be crushed to suitable size for container by means of the crane manipulator and be packed into the containers.

Automated and remotely controlled tools for the rotary manipulator

Tool	Range of application
Inside tube grinding unit	Separating pressure tubes, shafts, bushings
Circular cut milling unit	Circular cut of neutron shield insulation layers around pressure tubes

Abrasive wheel cutter	Linear cut of neutron shield insulation layers between pressure tubes
Miniature abrasive wheel cutter	Cutting-off piping and internals of thin walls
Plasma torch separating unit	Separating of internals with thick walls
Nut runner unit	Screwing off bolts
Vacuum unit	Sucking off steel shielding spheres & chips
Combined ball/jaw gripper unit	Picking and lifting spacers, plugs, shieldings from the fuel element arrangement & pressure tubes
Vacuum gripper	Picking & handling of flat and smooth parts
Universal latch gripper	Picking and handling large components inside the reactor and transporting to the crushing house

<u>Testing of tools</u>

The testing of tools - there are actually tooling machines - was performed in three stages:

- Cold run
  Functional test of equipment and proof of prespecified technical data
- Performance test at the model
  The equipment is tested for its efficiency at special models. De- termination of the most favourable parameters for the use at the model.
- Use of equipment with a manipulator, remotely operated at various reactor components.

For the testing of the total quantity of equipment a model of the lower neutral shield was fabricated, which was crushed and disposed of from the control room by remote operation.

The equipment used in the nuclear power plant, which require maintenance, can be tested at the second control station prior to application in the reactor. Small reconstruction and repair work at the tools and their preparation for use in the reactor are performed in an intervention room. A repair room is existing for major repair work.

7. PERFORMANCE OF THE WORK

The sequence of work had to be strictly performed according to the prespecified work stages, had however to be adapted to the respectively encountered circumstances and conditions due to the different actual constructional designs compared to the ones on the drawings.

During the current dismantling it has shown that some initially involved work could be manually performed, because the existing radiation was lower as originally assumed.

The reactor internals were separated with at the detachable and undetachable connections by means of the available tools, transported into the crushing station by means of grabbing and transporting equipment, there crushed to suitable sizes for container and packed into the containers put at disposal.

The net weight and the activity inventory is to be considered when packing into the various container types. The internals did not always match with the existing drawings, a fact that resulted in minor modifications of the tooling sets.

For example the following deviations were determined:

- The shielding spheres were found in raw pressed condition and not ground as assumed;
- the bolt head shape of some bolted connections was designed as a kind of hammer-head bolt instead of a hexagon;
- tack welds and welded connections were larger than assumed.

These differences unavoidably resulted in a minor delay of work. Important in this connection is however the fact that the existing tools can also be used for such deviations.

The work is performed in three shifts by approximately 70 men, with 20 men being engaged in protection against radiation, in order to keep the specified time schedule.

8. SURVEY OF FUTURE PROJECTS

The constuctional design of the nuclear power plant Niederaichbach is certainly one of the technically most sophisticated plants and consequently also a very difficult one for dismantling. As far as the radiation is concerned, this nuclear power plant is not problematic for dismantling.

The radiation of a pressure-water reactor is much more critical for the disposal work, i.e. a longer period of decay has to be considered prior to starting the actual dismantling. For reasons of protection against radiation the crushing of the internals would have to be performed under water.

Experiences gained from the dismantling of the nuclear power plant Niederaichbach will be helpful for further dismantling projects, however the competent Authorities will wait for the completion of the entire disposal of the nuclear power plant Niederaichbach before granting approval for further dismantling projects.

In the future the later disposal of a nuclear power plant should already be considered within the scope of construction and design, as already done for cars and other consumer goods.

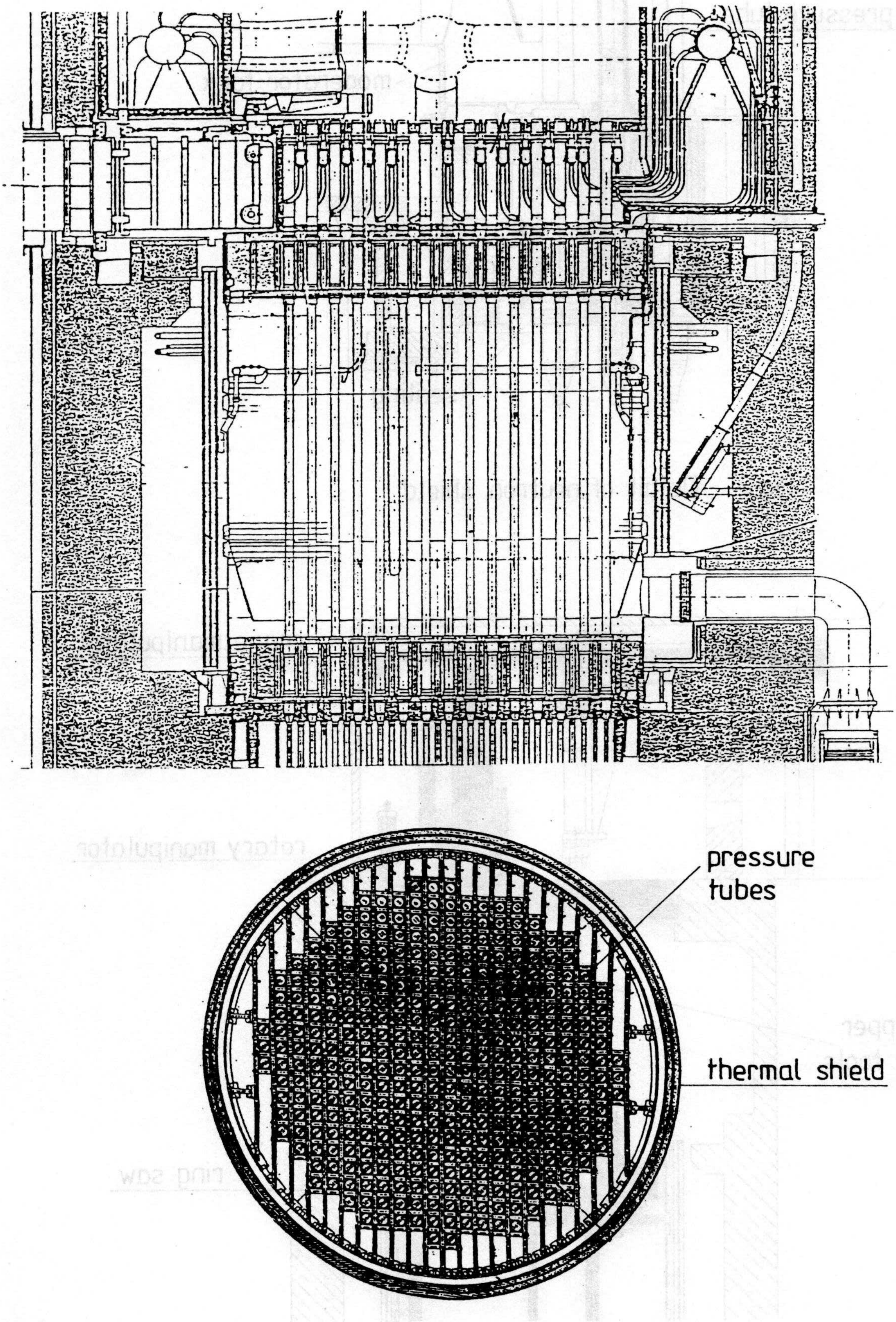

Fig. 1 Moderator tank

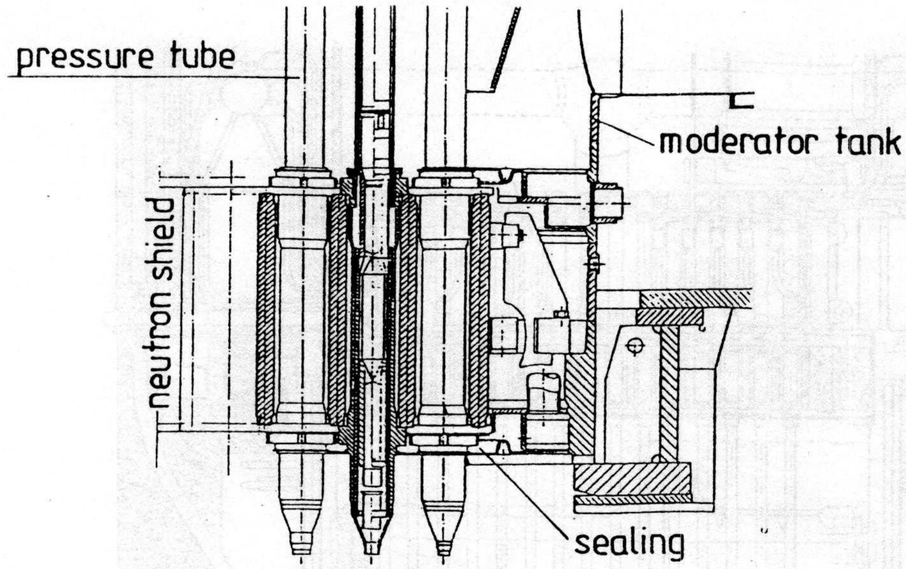

Fig. 2 Detail of neutron shield

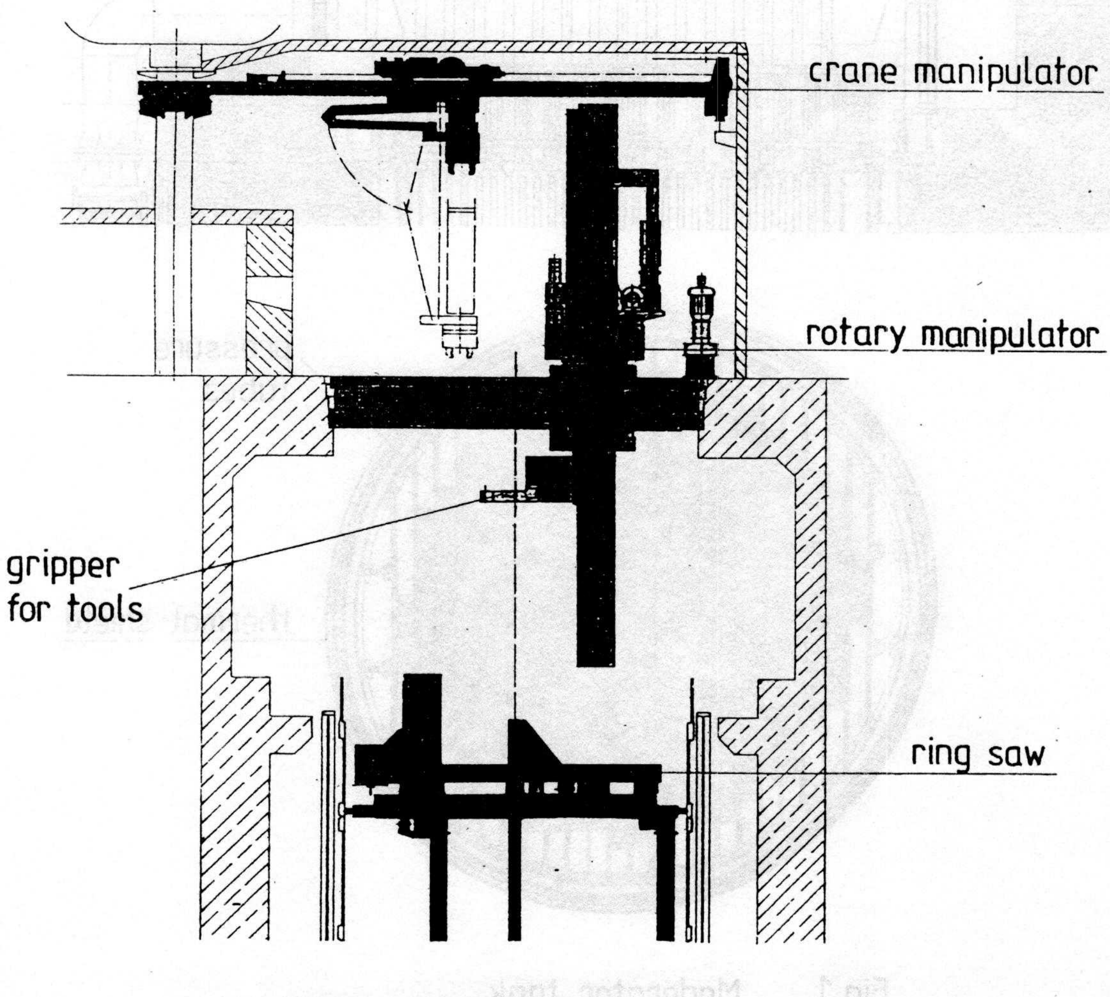

Fig. 3 Manipulators