Remote-Controlled Dismantling of the Thermal Isolation and Preparations for the Primary Shield Removal - 11279

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Introduction

The compact sodium-cooled reactor facility KNK was an experimental nuclear power plant with 20 MW of electrical power output. Initially, between 1971 and 1974, the plant was operated with a thermal core and referred to as KNKI. Between 1977 and 1991, it was run with a fast core as KNKII. The reactor is currently being completely decommissioned down to green field conditions in ten permission steps according to the German Atomic Law. The current permission step nine includes dismantling the thermal isolation, removal and cutting of the primary shield and dismantling the activated parts of the biological shield. Afterwards, the remaining auxiliary installations such as ventilation systems or electrical components can be removed. This removal is necessary for the subsequent free measurement and release from the Atomic Act at the end of the dismantling project. After the release, the demolition of the building with its remaining built-in structures will be carried out.

Dismantling of the thermal isolation

At the current state of the KNK decommissioning project, all sodium has been removed from the reactor. Therefore the follow-on works can be done under normal dismantling conditions within a nuclear power plant. This means that only the activity and the corresponding dose rates as well as the building conditions need to be taken into consideration for the dismantling. Due to the activation during operations the existing dose rate demands a remote-controlled dismantling of the core internals and the activated part of the biological shield. The Co-60 activity of the thermal isolation is approximately 6 E11 Bq and that of the primary shielding is approximately 1.3 E13 Bq. In addition to the dose rate, the lack of space further complicates the decommissioning process.

Figure 1 shows the setup of the remaining parts within the reactor core. Above the reactor core, an enclosure was constructed containing all the necessary tools such as cranes, manipulators and locking systems for the dismantling work. This enclosure was built for shielding and inerting. The inerting is no longer necessary since all sodium has been removed, but the necessity for shielding and avoidance of contamination spread still exists. Thus the enclosure needs to remain in place.

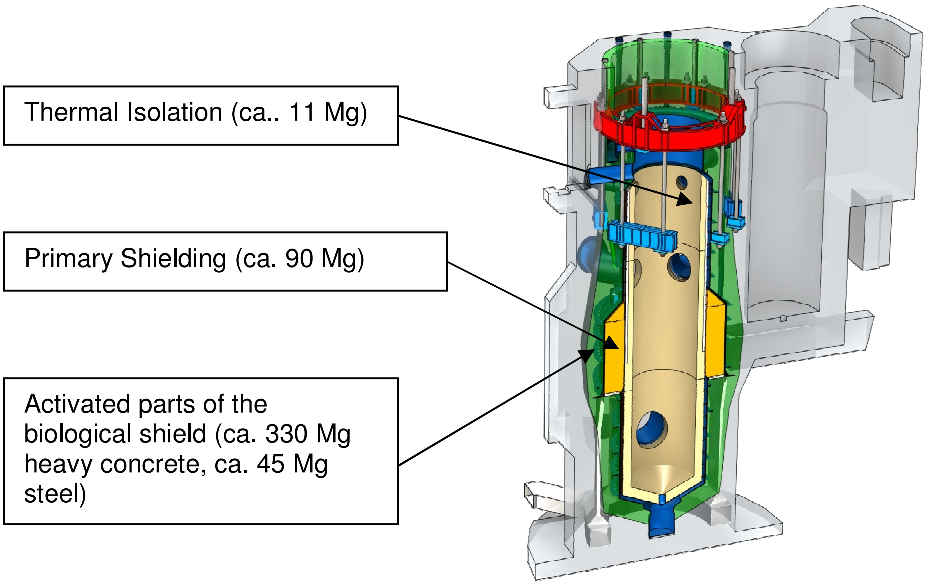

Fig. 1: Setup of the core internals such as thermal isolation, primary shield and the activated parts of the biological shield

The reactor shaft of KNK is lined with a thermal insulation consisting of brickwork with a thickness of 160 mm (upper parts) and of 250 mm (lower parts), a 90 mm thick layer of mineral wool and a 0.5 mm thick steel liner fixed by steel bolts. The total mass of the thermal shield is approximately 11 Mg. The dismantling of these components is currently performed with a remote-controlled multi-purpose tool called WTS, provided by Siempelkamp Nukleartechnik GmbH.

The WTS is attached to an existing crane above the reactor shaft. The electric and hydraulic lines use special multi-plug connectors on top of the machine which allow remote controlled couplings. In order to fasten the device securely within the reactor shaft, the WTS is equipped with two outriggers which can be pressed against the surrounding walls. The dismantling work is performed using a hydraulic manipulator system, positioned at the lower half of the machine. Several electric and hydraulic tools like a chipping hammer and an angle grinder are available which had to be adopted with handles and plug-in coupling suitable for remote controlled use.

Two drums, positioned on a telescopic drum handling unit underneath the manipulator working zone are used to collect the dismantled material. Pivoted guiding plates above the drums ensure that more than 90% of the dismantled material is directly collected. In order to replace full casks with empty ones, the drum carrier unit can be uncoupled and docked automatically without manual interference. All security relevant actions are designed to be redundant, the main functions of this machine can be performed by two completely independent systems. For instance, in case of breakdown of an electric drive, the affected function can be taken over temporarily by a hydraulic motor.

The WTS is currently operated about 12 hours per day in two shifts and a large part of the thermal insulation has already been successfully dismantled.

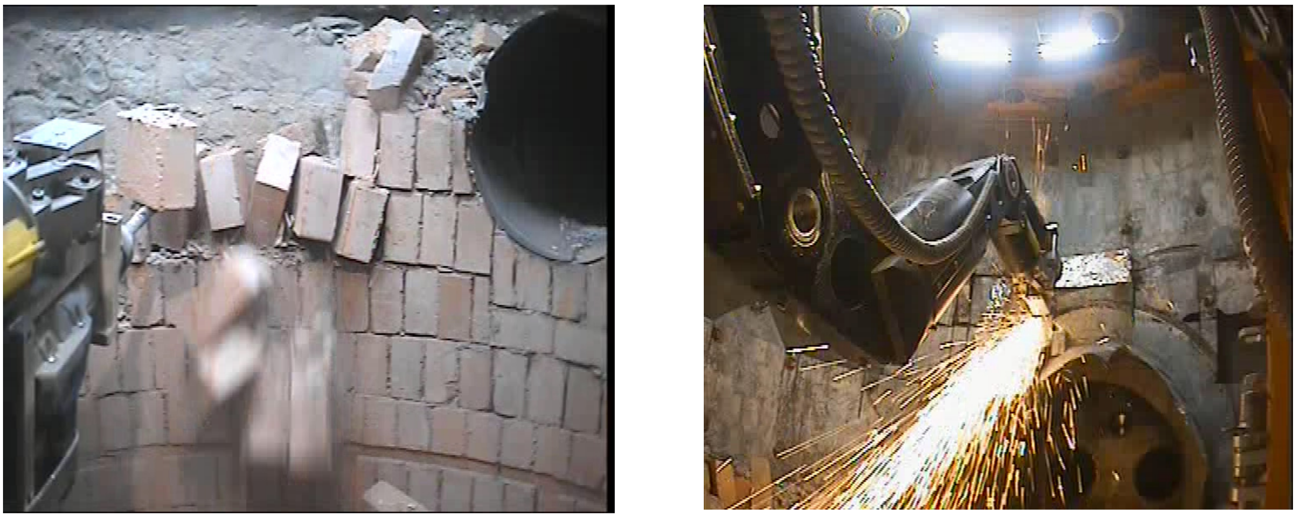

Fig. 2 Remote-controlled dismantling of chamotte brickwork and steel lining

Preparation of the primary shield removal

The primary shield of KNK consists of 12 cast iron segments, which are placed in a niche of the biological shield and surround the former reactor core. Their total mass is 90 Mg with a Co-60-activity of 1.3 E13 Bq with the heaviest segment having a mass of 15.5 Mg. The estimated dose rate is approximately 330 mSv/h. This conditions demand a remote-controlled removal of the primary shield. Due to the restrictions caused by the enclosure and the compactness of the plant no standard tool could be used for the removal. Additionally, the distance between single segments is only about 5 mm and the maximum lifting height is about 3 cm. The dismantling of these elements will be performed by a remote-controlled multi-purpose tool called HWZ, provided by Siempelkamp Nukleartechnik GmbH.

The HWZ is attached to the existing reactor crane, which has a maximum load capacity of 25Mg, thus limiting the admissible net operating weight of the HWZ. Also, the overall tool size is limited by the 2100mm diameter of the circular opening at the upper end of the reactor shaft. Due to these load and size restrictions, most parts of the machine had to be purpose-built.

In order to attach the device to the reactor shaft, the HWZ is equipped with four outriggers which can be pressed against the surrounding walls. A custom-built machining device, positioned at the lower half of the HWZ, is used to drill two holes into each of the shield elements for further handling. As the surface of the shielding elements is curved, the elements initially have to be milled in order to produce a plane surface. Subsequently the two holes with a diameter of 110mm and a depth of 335mm are drilled simultaneously. The semi-automatic machining device moves along three linear and two rotation axes to realize the complex movements required.

All security relevant actions are designed to be redundant, the main functions of this machine can be performed by two completely independent systems. For instance, in case of breakdown of an electric drive, the affected function can be taken over temporarily by a hydraulic motor.

To hoist the elements out of the reactor shaft, the HWZ is equipped with clamping mandrels. These tools can be inserted into the drilled holes and then tightened inside, thus achieving a firm connection with the cast iron components.

The dismantling process described above is currently tested in a mock-up of the reactor shaft. During this trial operation a replication of the heaviest element (16.6Mg) has already been successfully machined and hoisted out of the mock-up.

Fig. 3: Drilling and lifting up of the primary shielding segment in the mock-up

Summary

The remote-controlled dismantling of the thermal isolation and the removal of the primary shield within a compact nuclear research reactor cannot be done with standard tools. Special custom-built tools and systems are required, prototypes have to be designed, constructed and tested before their final adoption.

The smooth progress of the remote-controlled dismantling of the thermal isolation proves that the advance testing of the prototype tools is both necessary and efficient. Even with the existing restrictions due to dose rate, compactness and additional enclosure, a secure and fast dismantling process could be realized with very low down times.

The dismantling of the primary shield is the next challenge on the way to green field status. The first test results of the HWZ tool in the reactor mock-up show that the current plan for removing the segments is feasible.