DETAILS OF OPERATIONS PERFORMED BY THE REMOTE CONTROL ROBOT (CONCEPT) TO THE HORIZONTAL FUEL CHANNEL DURING DECOMMISSIONING PHASE OF NUCLEAR REACTOR CALANDRIA STRUCTURE.

PART I: OUTSIDE OPERATIONS

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Abstract: The authors contribution to this paper is to present a concept solution of a remote control robot (RCR) used for the horizontal fuel channels pressure tube decommissioning in the CANDU nuclear reactor. The authors highlight in this paper, few details of geometry, operations, constraints by kinematics and dynamics of the robot movement outside of the reactor fuel channel. Outside operations performed has as the main steps of dismantling process the followings: positioning front of Calandria structure at the fuel channel to be decommissioned, coupling and locking to the End Fitting (EF), sorting and storage extracted items in the safe container. All steps are performed in automatic mode. The remote control robot (RCR) represents a safety system controlled by sensors and has the capability to analyze any error registered and decide next activities or abort the outside decommissioning procedure in case of any risk rise in order to ensure the environmental and workers protection.

Keywords: Decommissioning, CANDU reactor, fuel channel, radiation protection

1. INTRODUCTION

Decommissioning the nuclear facility is a complex operation from point of view of process management. Considered the most important step in dismantling the nuclear reactor structure itself the decommissioning of fuel channels is performed as one of the last operations in this process. Because represents such a complex process the decommissioning of the fuel channels requires the maximum radiation protection degree and should be used special tools in remote control mode to perform it.

2. SHORT PRESENTATION OF THE DEVICE CONCEPT

The proposed concept solution of the Remote Control Robot (RCR), was designed in order to provide a fully protection of environment and personal against the nuclear radiation during the decommissioning process of the horizontal fuel channels in the CANDU 6 nuclear reactor.
2.1. GENERAL ASPECTS

Designed to work on the both sides of reactor (front and back) the Remote Control Robot (RCR) dismantles one by one the reactor fuel channel components. It’s operated by a complex platform equipped with a command panel, the general power supply, electrical actuators and geared motors. The platform allows the movements on all axis.

From point of view of RCR dimensions can be mentioned the followings:
- Length = 8.5 m, approx.
- Width = 1.3 m approx.
- Height = 1.7 m approx.

For platform as principal dimensions are:
- Length = 16.7 m, approx.
- Width = 7.3 m approx.
- Height = 11.9 m approx.

2.2. STRUCTURE ASSEMBLY PRESENTATION

The platform (P) is fixed from the beginning of the process on the floor of the reactor chamber in front (or back) of the calandria structure. The Remote Control Robot (RCR) also is mounted on the platform (see Figure 1):
1 - Platform
2 - Remote Control Robot
3 - Front side (or back side) of calandria reactor structure

![Figure 1. The Remote Control Robot on platform, in front of calandria structure](image-url)
2.2.1. PRESENTATION OF THE PLATFORM

Being fixed on the floor in the calandria structure chamber, the platform represents a strong steel structure. Having an access ramp this base allows the access of the forklifts (see Figure 2) to retrieve the container when the operations are finished every fuel channel. The components are: 1 – Access ramp; 2 – Fixed base; 3 – Mobile base; 4- Vertical support structure; 5- Sled for moving horizontally and vertically.

The movements of the structure are presented in Figure 3:

The access ramp (1) and fixed base (2) are fixed on floor, mobile base (3) allows one translation along the X axis, the vertical support structure (4) – joined with mobile base and the sled for moving horizontally and vertically (5) allows three degrees of freedom, one on each axis (see Figure 4)
2.2.2. PRESENTATION OF THE REMOTE CONTROL ROBOT (RCR)

The fuel of the CANDU 6 nuclear reactor is composed by fissile isotopes (U235, Pu239) and fertile materials (U238, U232). The nuclear radiation half-life for each isotope are specified hereunder:
- U235 has 704 million years
- U238 has 4.468 billion years
- Pu239 has 24110 years

Due to nuclear radiation (which has harmful effects on living organism through their ionizing effect on the molecular level) during handling of these materials is mandatory to consider all possible protection rules.

The Remote Control Robot (RCR) in currently proposed design is a compact and flexible structure and can perform all operations of the decommissioning process: extracting the channel closure plugs, cutting the pressure tube (PT) in many parts during extracting phase of it, extract and cut the end fitting (EF) in two parts.

The main parts of RCR are presented in Figure 5:
1 – safety bellows; 2 - connecting pipe; 3 – safety valve; 4 – tool chamber; 5 – external cutting device; 6 – rods chamber; 7 – safety container; 8 – motors chamber; 9 – chassis.

![Fig. 5. The Remote Control Robot (RCR)](image)

2.2.3. MOVEMENT OF THE REMOTE CONTROL ROBOT (RCR)

2.2.3.1. SAFETY BELLows

Safety bellows (the bellows is joined to the connecting pipe - see Figure 6):
- one translation on Z axis
- one rotation around the Z axis

![Fig. 6. The safety bellows - degrees of freedom](image)
2.2.3.2. CONNECTING PIPE
Connecting pipe (connected at the end fitting - see Figure 7):
- one rotation around the Z axis

![Fig. 7. The connecting pipe - degrees of freedom](image1)

2.2.3.3. SAFETY VALVE
Safety valve (it closes the fuel channel between some operations - see Figure 8):
- one rotation around the Y axis

![Fig. 8. The safety valve - degrees of freedom](image2)

2.2.3.4. TOOL CHAMBER
Tool chamber (the sliding holder tools are stored inside - see Figure 9):
- two translation movements: on x and Y axis

![Fig. 9. The tool chamber - degrees of freedom](image3)

2.2.3.5. EXTERNAL CUTTING DEVICE
External cutting device (to cut the extracted tubes - see Figure 10):
- one rotation around the Z axis
2.2.3.6. **RODS CHAMBER**  
Rods chamber (inside there is a support of rod tools - see Figure 11):  
- one translation on Y axis

2.2.3.7. **SAFETY CONTAINER**  
Safety container (from the beginning of operations is fixed on the chassis and will be removed from the RCR chassis when operations are finished with all extracted components inside, stored in safety conditions - see Figure 12):

2.2.3.8. **MOTORS CHAMBER**  
Motors chamber (fixed on the chassis - see Figure 13):
2.2.3.9. CHASSIS
Chassis (fixed on the platform supports by two strong supports - see Figure 14):

![Chassis on the supports of platform](image)

2.2.4. THE OUTSIDE OPERATIONS IN DECOMMISSIONING PROCESS PERFORMED BY THE REMOTE CONTROL ROBOT (RCR)

The Remote Control Robot (RCR) is designed to perform all operations in decommissioning process accordingly with all radiation protection rules. This process are divided into outside and inside fuel channel operations.

Could be defined as main outside operations performed the followings:
- positioning of the RCR in front of the fuel channel which should be decommissioned;
- set the angle position of fitting for End Fitting (EF) tube;
- secure the fuel channel by moving the RCR until the safety bellows touch the front side of the calandria structure;
- before starting the decommissioning sequences is mandatory to check the good alignment of RCR and perform all the measurements needed (distances, nuclear radiation level, etc.).

3. CONCLUSIONS

In respect with AECL (Atomic Energy of Canada Limited) rules and other international standards for ensure the maximum safety against the nuclear radiation during exploitation life, the proposed design of the Remote Control Robot (RCR) should be continuous upgraded.

All the components should be very carefully checked accordingly with maintenance check lists rules and for any deviation registered need to be considered corrective actions.

4. REFERENCES


