



## REMOTE CONTROL DECOMMISSIONING MACHINE FOR THE HORIZONTAL FUEL CHANNELS OF NUCLEAR REACTOR

Constantin Popescu<sup>1</sup>, Gabi Roșca-Fârtat<sup>2</sup>, Nicolae Pana<sup>3</sup>

<sup>1</sup>Polytechnic University, Bucharest, ROMANIA, puiu\_2001uss@yahoo.com.

<sup>2,3</sup>Polytechnic University, Bucharest, ROMANIA, rosca\_gabi@yahoo.com, npaniki@gmail.com

**Abstract:** The aim of this paper is to present a concept of the remote control decommissioning machine for the horizontal fuel channels of nuclear reactor. In this paper the authors present some properties of geometry, kinematics and dynamics of the decommissioning machine movement into the reactor fuel channel and a few details regarding the material thickness, according to the radiation protection procedures. The main stages of dismantling operation are: positioning, coupling and locking, operating accordingly with approved decommissioning procedures, sorting and storage extracted items in the machine container. All operating steps are designed to be automated and performed by one machine which shall provide radiation protection during the dismantling stages, ensuring radiation protection of the workers. The operations are monitored by the internal and external sensors and transducers, by cameras for the dismantling components video surveillance and pyrometer for temperature during the cutting process, in order to ensure assembly operating facilities and a permanent control. The remote control decommissioning machine has a safety system able to extract the tools from the channel in case of blocking or decommissioning activities disruption due to any error registered in order to ensure the environmental and workers protection accordingly with the Canadian nuclear regulations and the fundamental safety principles of the International Atomic Energy Agency (IAEA) Safety Standards.

**Keywords:** Fuel channel, decommissioning, dismantling operation,, radiation protection, remote control decommissioning machine

### 1. INTRODUCTION

Considered the most important in dismantling the nuclear reactor structure, decommissioning of fuel channels represents one of the last operations which is performed in the process of decommissioning the nuclear power plant. Due to safety reasons, should be used special devices with command and control from the outside (in remote control mode) and supervised by an operator.

### 2. GENERAL PRESENTATION OF THE DEVICE

Hereunder, the authors proposed a constructive solution for a Remote Control Decommissioning Machine (RCDM) designed in order to provide a fully protection of personal and environment against the nuclear radiation during the decommissioning process of the horizontal fuel channels in the CANDU 6 nuclear reactor.

#### 2.1. General considerations

The Remote Control Decommissioning Machine (RCDM) should be able to ensure full radiation protection of personal and environment during all decommissioning steps performed.

The Remote Control Decommissioning Machine (RCDM) is prepared to work on the both sides of reactor (front and back) for dismantling one by one the reactor fuel channels.

The Remote Control Decommissioning Machine (RCDM) is operated by a complex platform equipped with the general power supply, command panel, electrical actuators and geared motors to allow movement on all axis. All operations are supervised by an operator.

The principal physical characteristics of RCDM:

- Length = 8.5 m, approx.; Width = 1.3 m approx.; Height = 1.7 m approx.

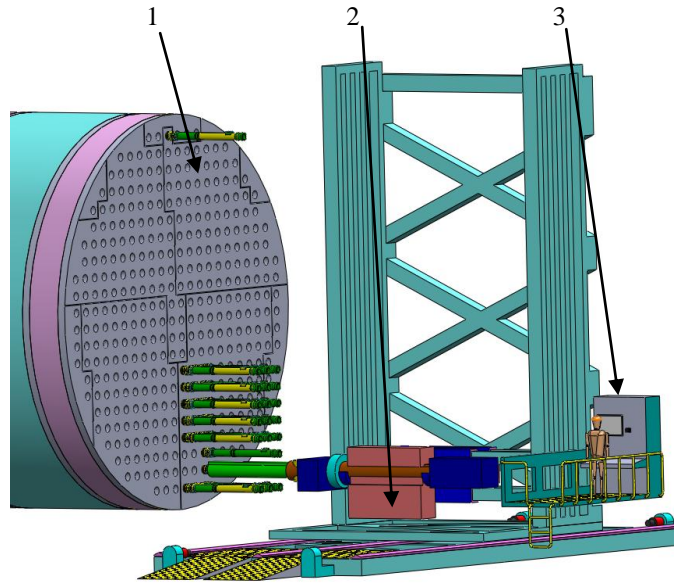
The principal physical characteristics of platform:

- Length = 16.9 m, approx.; Width = 9.3 m approx.; Height = 11.8 m approx.

### 2.2. Device assembly presentation

The Remote Control Decommissioning Machine (RCDM) with its platform (P) are fixed at the beginning of decommissioning process on the floor of the reactor chamber in front (or back) of the calandria structure (see Figure. 1):

- 1 – Front side of calandria reactor structure
- 2 - RCDM
- 3 - Platform

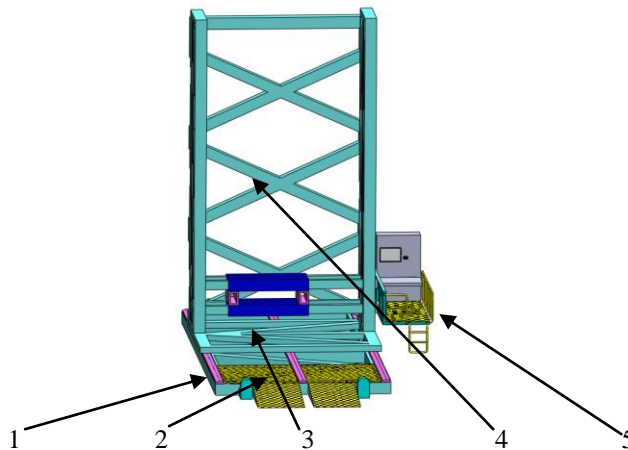


**Figure 1:** The Remote Control Decommissioning Machine on platform, in front of calandria structure

### 2.3. Platform presentation

The platform is a super rigid steel structure and has a base fixed on the floor of the calandria structure chamber. This base allows the access of the forklift to retrieve the safety container at the end of operations for every fuel channel. From this reason the base is equipped by an acces ramp (see Figure. 2):

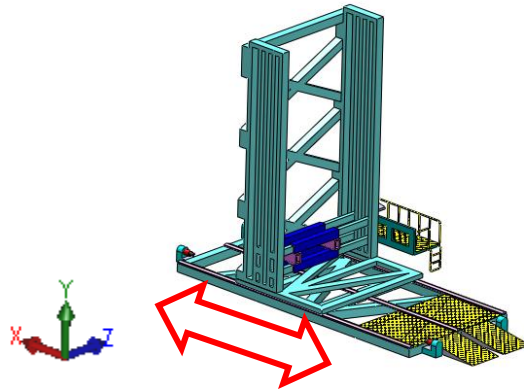
- 1 – Fixed base
- 2 – Access ramp of the forklift
- 3 – Mobile base
- 4- Vertical support structure
- 5- Command platform



**Figure 2:** The Platform

In the Figure 3 are shown degrees of freedom allow by the flexibility of structure:

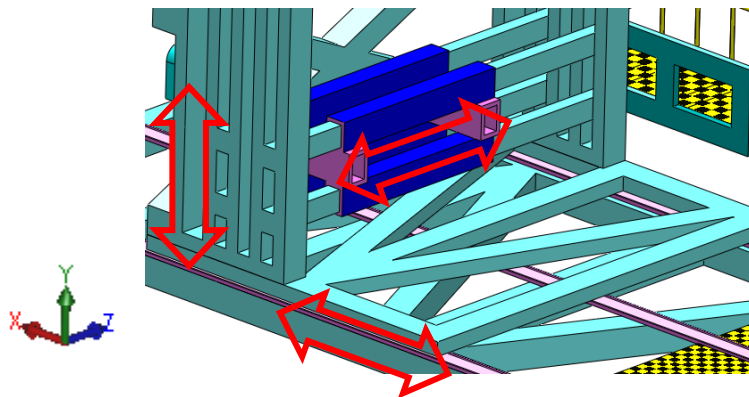
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**Figure 3:** The platform - degrees of freedom

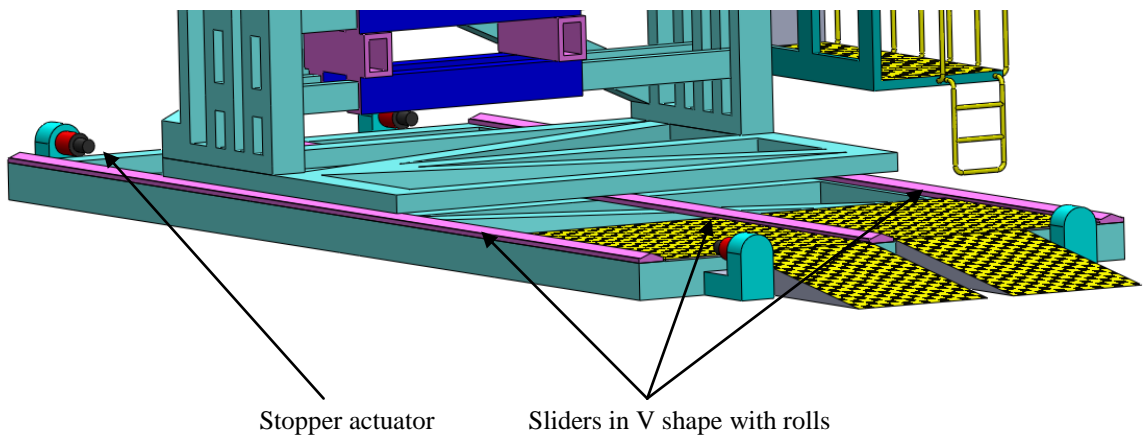
- 1 – Fixed base – fixed on floor
- 2 – Access ramp of the forklift – fixed on floor
- 3 – Mobile base – one translation along the X axis
- 4- Vertical support structure – joined with mobile base
- 5- Command platform – joined with mobile base,

The Platform is equipped by sleds for moving horizontally and vertically allows three degrees of freedom, one on each axis (see Figure. 4)



**Figure 4:** The mobile sled - degrees of freedom

Grace of the three sliders in V shape with rolls, the quick movement of the mobile base along the X axis is limited by the stopper actuators which are on each side of fixed base (see Figure.5).

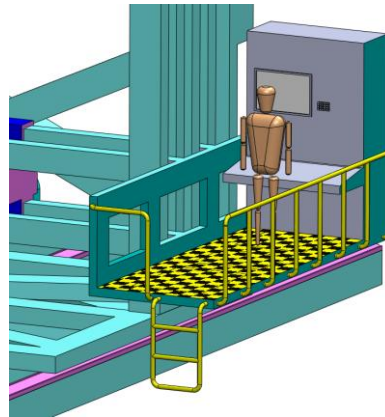


Stopper actuator

Sliders in V shape with rolls

**Figure 5:** Sliders on fixed base and stopper actuators

The Platform has in its structure a command platform on which is already integrated the command desk supervised by an operator. The system allows to fully control the RCDM by a Programmable Logic Controller (PLC) and operated with a Human Machine Interface (HMI) (see Figure.6).



**Figure 6:** Command platform with command desk and operator

#### 2.4. The Remote Control Decommissioning Machine (RCDM) presentation

The nuclear reactor represents a very complex construction in which is maintained a controlled fission chain reaction of heavy isotopes.

In condition of maintaining the chain reaction, the producing neutron fission has to be balanced by their loss by absorption or eliminate outside. The nuclear radiation have harmful effects on living organism through their ionizing effect on the molecular level.

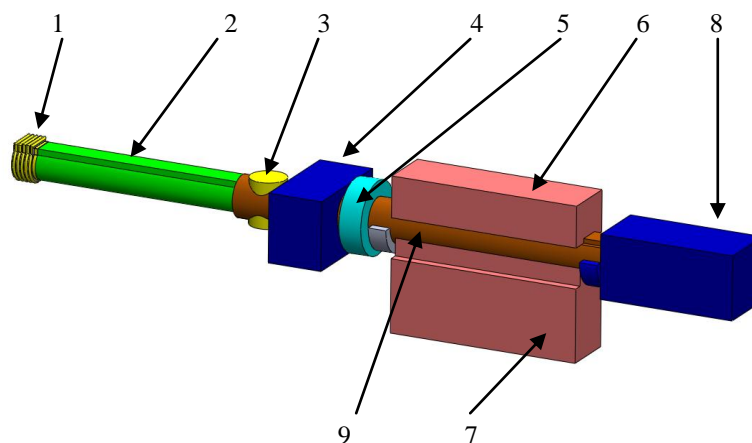
In handling process of these materials we have to consider all possible protection rules as mandatory to be applied.

The proposed solution design is a Remote Control Decommissioning Machine (RCDM) which has a compact and flexible structure able to perform all operations in decommissioning process as follows: extracting the channel closure plug and the channel shield plug, cutting the pressure tube (PT) in four parts during extracting phase of it, extract and cut the end fitting (EF) in two parts when extract it.

The Remote Control Decommissioning Machine (RCDM) is a closed system, all extracted components remained stored inside of the safety container.

The main components of RCDM are (see Figure. 7):

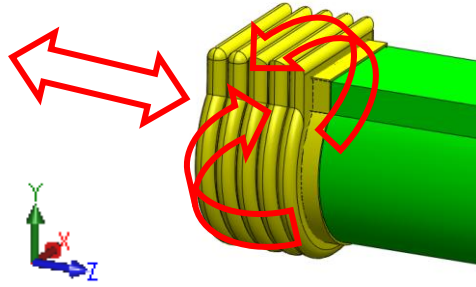
- 1 – safety bellows; 2 - connecting pipe; 3 – safety valve; 4 – tool chamber; 5 – external cutting device;
- 6 – rods chamber; 7 – safety container; 8 – motors chamber; 9 – RCDM chassis



**Figure 7:** The Remote Control Decommissioning Machine (RCDM)

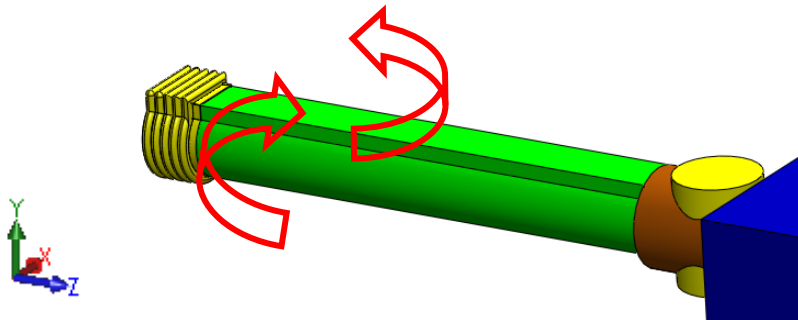
Considering the structure of the RCDM, this allows following the degrees of freedom (see Figure.8):

1 – Safety bellows - one translation on Z axis and one rotation around the Z axis (the bellows is joined to the connecting pipe) (see Figure.8):



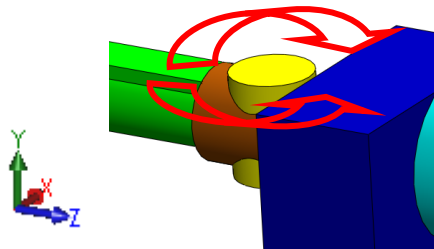
**Figure 8:** Degrees of freedom for the safety bellows

2 - Connecting pipe - one rotation around the Z axis (needed to allow connection with the end fittings which has not in vertical position the water pipe connection) (see Figure. 9):



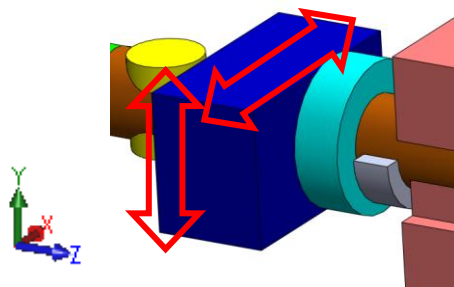
**Figure 9:** Degrees of freedom for the connecting pipe

3 - Safety valve - one rotation around the Y axis (needed to allow closing of the fuel channel during some operations) (see Figure. 10):



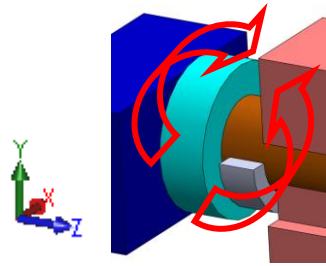
**Figure 10:** Degrees of freedom for the safety valve

4 - Tool chamber - the inside support of head tools (stored inside) has two translations: on X and Y axis (see Figure. 11):



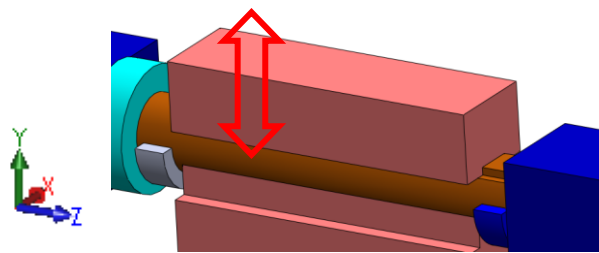
**Figure 11:** Degrees of freedom for the tool chamber

5 – External cutting device – one rotation around the Z axis (needed to cut the extracted tubes) (see Figure. 12):



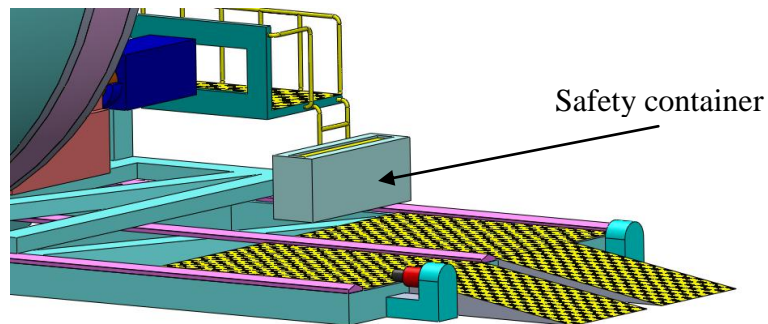
**Figure 12:** Degrees of freedom for the external cutting device

6 – Rods chamber – inside there is a support of rod tools which has one translation on Y axis (see Figure. 13):



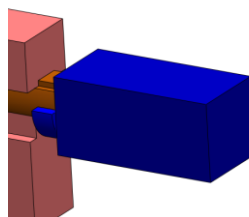
**Figure 13:** Degrees of freedom for the rods chamber

7 – Safety container – could be removed from the RCDM chassis when operations are finished and have inside all extracted components, stored in safety conditions (see Figure. 14):



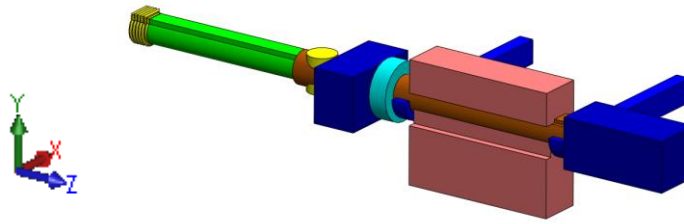
**Figure 14:** The safety container in removed position

8 – Motors chamber - fixed on the RCDM chassis (see Figure. 15):



**Figure 15:** The motors chamber on the RCDM chassis

9 – RCDM chassis – fixed on the platform supports (see Figure. 16):



**Figure 16:** The chassis on the supports of platform

## 2.5. The order of operations in decommissioning process

The Remote Control Decommissioning Machine (RCDM) is designed to perform all operations in decommissioning process on the both faces of calandria structure as follows:

- Starts on back face of calandria:
  - o extracting the channel closure plug and stored in the safety container;
  - o extracting the channel shield plug and stored in the safety container;
  - o cutting the pressure tube (PT) at one end
  - o extract the end fitting of this side
  - o cutting end fitting (EF) in two parts and stored them one by one in the safety container.
  - o close the calandria pipe with a safety lid
- Move the platform on front side of calandria structure and performs:
  - o extracting the channel closure plug and stored in the safety container;
  - o extracting the channel shield plug and stored in the safety container;
  - o cutting the pressure tube (PT) at one end
  - o extract the end fitting of this side
  - o cutting end fitting (EF) in two parts and stored them one by one in the safety container.
  - o extract the pressure tube (PT)
  - o during the extracting phase PT is cut in four parts and stored them one by one in the safety container.
  - o close the calandria pipe with a safety lid

## 3. CONCLUSIONS

The proposed design of the Remote Control Decommissioning Machine (RCDM) could be continuous developed in respect with AECL (Atomic Energy of Canada Limited) rules and other international standards to ensure the maximum safety against the nuclear radiation during exploitation life.

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