THE EXPERIMENTAL MODEL OF SIMULATOR FOR CANDU600 FUEL HANDLING SYSTEM

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Abstract

Personnel training are a main topic in the security and reliability of several industrial processes. The simulator is a physical device that reproduces real operation of a device used in a production process technology. Typically, a simulator is intended to train the operators to work properly with the real device in the production process, but simulators can be frequently involved in the research and evaluation of human operators' performance. Process simulation has a significant role in the training of operators of nuclear power plants (NPPs). To ensure the NPP safe operation, protection of workers and the environment, the training of its operators in all plant operating modes is essential. In the perspective of design and realize a CANDU600 Fuel Handling Simulator at the F/M Head Test Rig facility from Institute for Nuclear Research Pitesti, Romania, to be used for training of operating personnel, we made and present the experimental model of the simulator (MESI). This model allows setting of the requirements and fabrication details, especially for the software kit that will be designed and implemented on the main simulator. Currently, the experimental model MESI is built and passed the final stage of dedicated software testing. This paper presents the hardware structure, the simulation algorithms implemented as ISaGRAF software modules and the dedicated human-machine interface (HMI) for the experimental model of CANDU600 Fuel Handling Simulator.

Keywords: *CANDU Fuel Handling System, Training, Simulator*

Introduction

Simulation can be defined as a design process of a real system model as well as performing of the tests using this model in order to understand the system behaviour and/or to assess different strategies to operate this system. In other words, it is necessary as model to be designed so that its behaviour under action of stimulus to imitate the real system behaviour at similar perturbation.

Simulation is one of the most powerful available tools for the design or operation heads of the complex processes and systems. In a world being in competitive progress, simulation became an indispensable methodology to solve the technical issues for engineers, designers or operators. It makes possible study, analysing and assessment of the real systems, in a virtual environment where, the powerful means for scientific analysis are already available.

The major role of plant processes simulation is supporting the training and retraining activities of the operators, where can't be performed on real installation, in abnormal, outstanding or emergency operation condition.

Institute for Nuclear Research Pitesti coordinates a R&D program supporting the research on technologies and equipments to simulate the Fuel Handling System (FHS) components. Its generic task is development of techniques and technologies for simulation of the system component parts operation, dedicated for the operators' skills improvement and professional testing.

Among the current tasks of this research direction, are:

- performing a technical design of a FHS simulator (SISMC), independent from the F/M testing rig control room - completed task;
- design and fabrication of an experimental model (MESI) of the independent FHS simulator. Now, construction and functional tests of the equipment are completed, and implementation of corresponding software kit is following. After the experimental model will be ripen and will allow setting of a consistent constructive requires and detail kit, it shall continue with the SISMC detailed design elaboration and, finally, with its execution.

The simulated system

The nuclear Fuel Handling System (FHS) is a complex equipment, component part of the nuclear CANDU600 type reactor, consisting of all equipment taking part to transfer the fresh nuclear fuel from deposit in the reactor, and then to the transfer of the spent nuclear fuel from the reactor in the cooling and storage pool.

FHS contains two Fuelling Machine (F/M) Heads, two carriage with corresponding rails and two bearing assemblies crane / column of the reactor placed on both reactor sides, two assemblies for fresh nuclear fuel refuelling, for spent nuclear fuel discharge and for F/Ms calibration, each placed in the maintenance ports, a spent nuclear fuel transfer system with associated auxiliary elements, supply sources and control systems.

The main function of the fuel handling system is to allow the fuel replacing during reactor operation, with enough high replacement rate to allow the reactor continuous operation at full power [1]. Depending on the nature of the operations performed, the FHS can be structured in 3 main parts: the equipment to transfer the fresh nuclear fuel, the fuelling machines, with the mechanisms providing motion and its positioning on the fuel channel of the reactor, as well as the equipment to transfer the spent nuclear fuel.

The F/M Head, main component of FHS, is a mechanical robot with hydraulic actuators, having as main role fuelling of the reactor with new nuclear fuel and the nuclear spent fuel discharge (see Fig.1).

To perform these operations in the nuclear power plant (NPP) are two F/M Heads, that operates simultaneous on the same fuel channel, upstream supplying with fresh fuel and downstream taking over the spent nuclear fuel.



Fig.1. The Fuelling Machine Head

The F/M head has as components the following main subassemblies:

- *antenna*, signalling the accidental contact of the head with an obstacle during its advancing to the fuel channel;
- *snout clamping*, through it the sealed coupling of the F/M head room to the fuel channel is made. The other functions are: signals rough misalignment in the vertical plane related to the fuel channel end fitting, sensing the mechanical contact of the sealing surfaces, makes connecting to the end fitting, and mechanical locking the connection against accidental decoupling;
- *magazine*, in whose 12 tubes are stored the fresh and spent fuel bundles, as well as tools or auxiliary devices required during technological operations;
- *three telescopic pushers or rams* (B Ram, C and Z) with hydraulic driving, the tools being actuated by them and the auxiliary devices in order to open or close the fuel channel, as well as to transfer the nuclear fuel to or from F/M magazine;
- *separators*, used to sensing the mechanical contact of rams with fuel bundles string, as well as to split remained fuel bundles which will be transferred in F/M magazine.

Advantages of the simulator use

Analysing different variants of simulator, with the complexity level desired to be reached by it and of the training program existing now in the NPP, has been identified the following advantages, both economical and with impact on quality of the training process [2]:

- Allow licence and re-licence of the operator in an environment without risks, similar to the reactor control room, where the operators can focus on the process free of responsibility stress in case of first time operation into a real and potential dangerous installation;
- Concentration of training period, resulting in training period time reducing;
- Saving direct costs, for each operator, by training time reducing;
- Training time reducing has also the advantage to rise in student flow being in training, and thus at administrative level can cope easy with staff turnover;
- Piloting, on boundless time and repeatable, of installations by the student, both in automatic and manual regime, leading to consolidation of professional knowledge and release of the operation stress in high risk conditions;
- Accommodation of future operator to entire operation set executing in the control room during refuelling activities, and especially to operation in manual regime, that are performed in the NPP only in event conditions;
- Implementation of lessons having technical attractive contests integrated to simulator and teaching the operator by modern e-learning methods;
- Implementation of a consistent kit of questionnaires and automat tests, whose difficulties gradually increasing during the training period, allowing a rigorous monitoring of the training level accumulations reached by the student;
- Execution of the control desks such as to remake in detail the aspect and structure of desks from reactor control room, so as the future operator, after end of training program, will be able to operate directly and easily the real installation;
- Simulation of a large events set in exploitation of FHS that requires the operator to understand, to find out and to apply, on short term, solutions to normalize these conditions;
- Quick and safe evaluation of some new operating procedures, for special conditions that can't be reproduced without risks in real installation;
- If is necessary, can perform on simulator both change check, testing and validation of the algorithms of real software, before implement them on the process computer in the reactor control room;
- Simulator can provide an ideal working environment for the automatists and operators to improve the adjusting factors of the adjusting device, and to practise automatic control circuits setting, respectively;
- Allow testing of new conditions, uncommon, on which there isn't previous experience;
- Allow slowing down of some processes and real, quick phenomena, and thus the efficient analysis of them, an impossible thing to do on real system.

Experimental Model of the Simulator (MESI)

Hardware Structure

To reach a high quality technical and economic standard level of the FHS operation, exploitation, and maintenance activities, development of high performance simulator equipment is considered useful. It mainly allows training by practice, and initial or periodic training of the FHS operation staff's skills, and the impact study of some changes in the system structure or parameters, before bringing these changes in operation [3].

As a first stage in its execution, proposed making of an experimental model simulator MESI allowing setting the requirements and fabrication details, both for the SISMC simulator hardware, especially for the software kit shall be designed and implement on it. Shall be designed and verified, before implementing, a large events set in FHS operation, also, that require from operator to identify and apply the solution to recover the normal operation state.

MESI reproduce the minimum requirements of equipment and instruments existing in the control room, for partial but coherent simulation of the technological installations feedback from FHS. The technological area covered, from economical and practical reasons, shall focus exclusively on simulation of F/M head exploitation, during operations developed on the fuel channel, considering this fact sufficient to reach the goal for the equipment being built.

MESI allows the accurate execution of the entire operation set developing commonly during refuelling of the nuclear fuel in reactor, both in automatic and manual working regime, confined to operate only on the fuel channel, indifferently the machine is upstream or downstream working to supply fresh fuel or to receive the spent fuel.

The experimental simulating equipment (see Fig.2), consists of three bodies: two desks, identical sized, including the control and checking elements (switches, lights, analogic and digital instruments, automatic controller), and a third body, central placed and lower height, sufficient to connect the process computer assigned.



Fig.2. MESI – The Experimental Model of Simulator

The desks are structured on sections (or panels), having the following constitution or functions:

- control and alarm of in/out positions of the left and right separator stoppers; control and alarm lock/unlock positions for the locking latches of the stoppers
- control and alarm in/out positions of left and right separator feelers (sensing element); indicate the feeler's positions
- control and alarm in/out positions of the left and right separators retractors; indicate the retractors positions
- control and indicate advanced/retracted positions of Z ram; signals to lubricate telescopic ram assembly
- control and indicate advanced/retracted position of B ram; control and indicate the control; indicate the supply flow rate, selection and indication of the selected force for ram driving
- order the electric power supply of the simulator; selection of the by-pass inter-locking position for the B ram, stoppers, feelers, magazine and high pressure valve
- driving of clockwise/counter-clockwise rotation of the magazine; fine/coarse indication of the magazine selected job position
- indicating magazine supply temperature; flow rates indications on the supply and return lines; driving of high pressure valves, of magazine supply and return
- control magazine water supply pressure; indication, selection and alarm the pressure level, alarm the magazine water temperature.

In the manual working mode, all the rotary switches on the simulator front panels are on ″manual″ position. The manual controls, performed at the experimental simulator desks, have send to process them, as analogic or digital inputs, to the process computer, following to signal or indicate information regarding the equipment or simulated elements on desks through its analogic or digital outputs.

In the automatic working regime all the rotary switches of the desks are actuated on ″automat″ position. Using the process computer in the automat working regime can be issued controls from assigned keyboard, to perform step by step, semi-automatic or complete automatic simulation.

Starting of the automatic control is lightening on the control panels by digital outputs of the process computer. On the panels of two bodies shall be indicated and signalized the equipment simulated states by analogic and digital outputs supplied by process computer.

Software Development System

The process computer is an OS9 machine, PEP Modular Computers manufactured in Germany, with VM42 motherboard, equipped with Motorola MC68040 CPU. Process interface from OS9-VME computer structure ensures type and number of simulation signal for the experimental model, being equipped with appropriate analogue and digital I/O modules [4].

The main programming environments used to develop simulation software for fuel handling system assemblies included in the experimental model are installed on MS-WINDOWS/ix86 type computers.

The chosen type of topology implementing open network concept, allows interconnection different software/ hardware platforms, between different development systems and VME system running an operating system OS9/68k with facilities for real-time multi-user and multitasking:

- ISaGRAF allows implementation of logical part of the software package, data management and data acquisition.
- Facilities for Historian viewing and recording for analogue and digital values from simulation process are implemented in LabView graphical programming language.
- Acquisition tasks and system tools of the simulator are developed using the cross-compiler Microware Hawk.

The development system provides facilities for viewing / storage/printing logs and operating alarms. Viewing the technological parameters evolution in graphical form sizes (in engineering units) is an important component of the experimental model, also hosted on Development System.

Simulation algorithms

Computer simulation of an existing physical system involves creating its mathematical model. Such a model is often obtained as a result of the identification system, or less frequently based on structural analysis, when possible.

Significant resources have been used for modelling distributed technology of independent functional modules, designing and testing tools dedicated to functions such as:

- Real-time simulation of machine behaviour when responding to commands from the operator or status of other parts of the machine changes as a result of other controls, mechanical linkages or interlocking technology;
- Creating databases, populating them with information, administration, maintenance tools and data security procedures to enable safe storage of information to be used concurrently by different application programs, including data from the calibration of technological parameters and present information to the operator;
- Secure communication mechanisms between concurrent tasks developed in different programming environments;
- Operational administration for functions of real-time data acquisition and acquired data verification tools;
- Viewing / recording HMI with local or remote access for programs on-line and off-line;
- Integrated management procedures and rules for users using both operating system functions and mechanisms OS9/68k application;
- Administration of handling errors and software maintenance;
- Defining technological jobs and managing their execution, for the operating mode with automatic controls of experimental model.

Projecting and implementing simulation algorithms for B Ram Cylinders and Latch of F/H Machine Head

Implicated Devices in simulation of B Ram cylinders and Latch functioning presents 2 types of signals:

- Analogue output with proportional evolution
- Analogue output with ″saw tooth″ evolution with pass through 0.

B Ram simulation

B Ram subroutine must ensure generating of analogical signals that simulates B cylinder position when it moves or stay, in contact with different elements from the inside of F/H Machine Head Magazine or inside the fuel channel [5]. Automation devices, at B Ram, realizing the lead, control of its position are simulated through AO signals and DI, signing on operator panel being through some DO signals.

Device	SIM F/H	Indicator
Coarse trimmer potentiometer B Ram main Coarse trimmer potentiometer B Ram reserve	AO_01	Voltmeter
Fine trimmer potentiometer B Ram main Fine trimmer potentiometer B Ram reserve	AO_02	Voltmeter

Advance B Ram	DI_02	DO_01
Retract B Ram	DI_03	DO_02
B Ram at high speed	DI_04	DO_03
B Ram at medium speed	DI_05	DO_04
B Ram at low speed	RESET	DO_05

Generating of analogue/digital signals respects the algorithm given in Fig. 3.

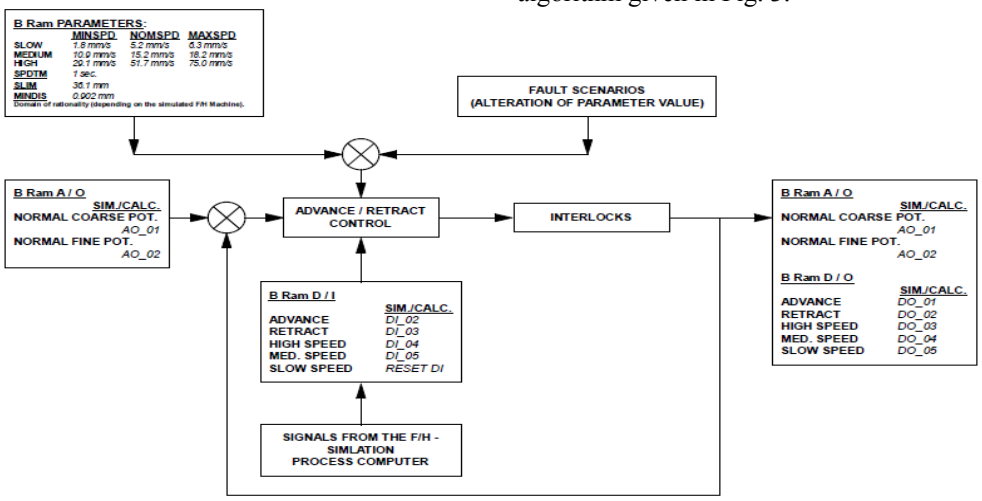


Fig.3. Simulation algorithm for B Ram signal

B Ram simulation subroutine needs some parameters: C_HMPOZ(0,3366V), F_HMPOZ(2,45V) = values in Volts, read on the coarse potentiometer, and fine one, when B Ram can be found at Z position (HOME).

B Ram speed domains are the following:

MINSPD	= min. speed	MAXSPD	= max. speed
SLOW	= 1.8 mm/s	SLOW	= 6.3 mm/s
MEDIUM	= 10.9 mm/s	MEDIUM	= 18.2 mm/s
HIGH	= 29.1 mm/s	HIGH	= 75.0 mm/s

SPDTM = time to reach some speed = 1.0 s

MAXRD = max. value read on the fine trimmer potentiometer = 4.9 V/ 26 mm

Coarse potentiometer range = 0 - 4.9V (0 - 3620mm)
Fine potentiometer range = 0 - 4.9V (0 - 26 mm)

B Ram nominal speed
SLOW = 5.2 mm/s
MEDIUM = 15.2 mm/s
HIGH = 51.7 mm/s

The information must be found in the application database.

By positioning we understand moving (by acting some outs) to a point (defined by a Set Point value). The moving speed can be modified with the selection switch of B Ram moving speeds. In case of B Ram simulation (see Fig. 4) we will have electrical signals of type ramp (AIs) in the domain 0-5 V, with signal saturation at positioning on set-point or at mechanical stop in the described situations and digital signals at levels 0 and 24 V [5].



Fig. 4. B Ram – Simulator Console

Simulation of B Ram semiautomatic mode operation

a) Positioning control B Ram with coarse potentiometer to a specified position at low speed [7]. Insert the appropriate mnemonic from the alphanumeric keyboard [7].

Creates the initial conditions for:
- B Ram position > FINLIM = limit control on fine potentiometer
- B Ram position < SETPOINT value corresponding to the position (ADVANCE).

Verify program loop:
Use coarse potentiometer for position indication. Set the digital outputs accordingly (see Fig. 5):
- DO_01 = SET / DO_02 = RESET, the direction of movement of the B Ram is ADVANCE,
- DO_03 and DO_04 = RESET / DO_05 = SET, the speed of B Ram is selected at SLOW value.

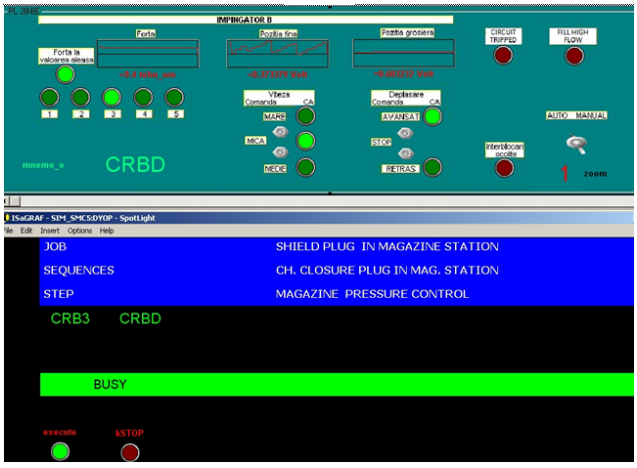


Fig.5. B Ram advance at low speed

b) Positioning control B Ram with coarse potentiometer to a specified position with medium speed [7]. Mnemonic CRBM is introduced. Insert using the alphanumeric keyboard corresponding mnemonic (CRB*).

Creates the initial conditions for:
- B Ram position > FINLIM = limit control on fine potentiometer
- B Ram position < SETPOINT value corresponding to the position (ADVANCE).

Verify program loop:
Use coarse potentiometer for position indication. Set the digital outputs accordingly (see Fig. 6):
- DO_01 = SET / DO_02 = RESET, the B Ram direction of movement is ADVANCING;
- DO_03 and DO_05 = RESET / DO_04 = SET, the speed of B Ram is selected at MEDIUM value.

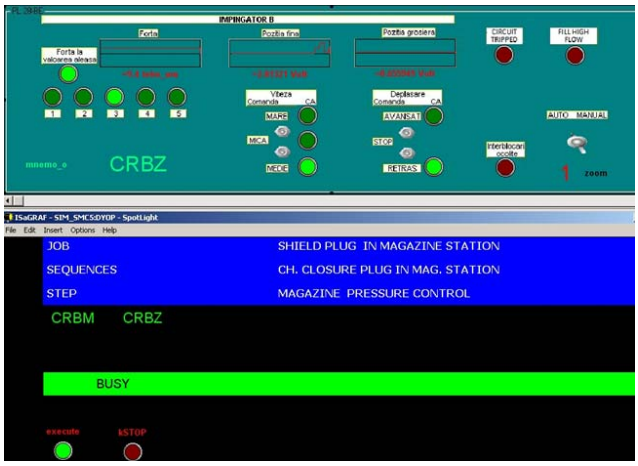


Fig.6. B Ram advance at medium speed

c) Positioning control B Ram with coarse potentiometer to a specified position at high speed [7]. The appropriate positioning mnemonic is inserted from the alphanumeric keyboard [7].

Creates the initial conditions for:
- B Ram position > FINLIM = limit control on fine potentiometer
- B Ram position > SETPOINT value corresponding to the position (ADVANCE).

Verify program loop:
Use coarse potentiometer for position indication. Set the digital outputs accordingly (see Fig. 7):
- DO_01 = RESET / DO_02 = SET, the direction of movement of the B Ram is RETRACT,
- DO_04 and DO_05 = RESET / DO_03 = SET, the speed of B Ram is selected at HIGH value.

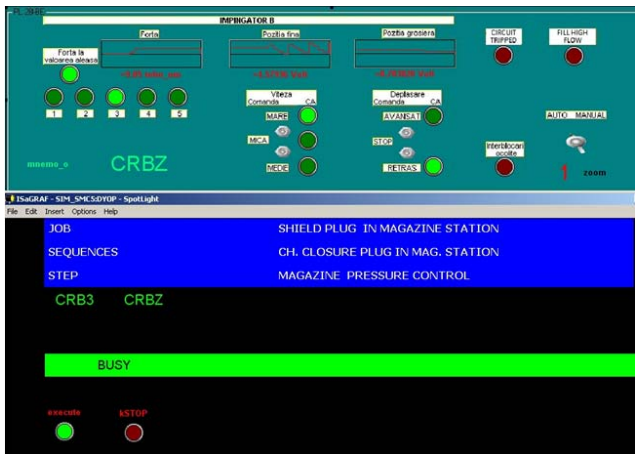


Fig.7. B Ram retract at high speed

Latch Ram simulation

Simulation subroutine of functioning Latch Ram generates electrical signals which characterizes positioning move of bolt cylinder - Latch Ram to a certain position. Automation devices of Latch RAM making the lead, its positioning control are simulated through AO signals and DI, flagging on operator panel being through some DO signals [5].

Device	SIM F/H	Indicator
Trimmer potentiometer Latch Ram main Trimmer potentiometer Latch Ram reserve	AO_04	Voltmeter
Advance Latch Ram	DI_12	DO_14
Retract Latch Ram	DI_13	DO_15

Latch Ram subroutine uses technological data set memorized in database specific modules:

CKTIME = Latch Ram completing time = 60 s
MINSPD = min. speed = 0.89 mm/s
MAXSPD = max. speed = 20.9 mm/s
Nominal speed =1.8 mm/s
SPDTM = time to reach some speed = 1.6 s
Maxtravel = max. race drive = 34 mm
TLL = tolerance to setpoints SPLL = 1.8 mm/s

The domain of potentiometer measuring for Z cylinder position is 0 - 4.9V in 10 rounds of potentiometer, same as 0 - 43.7 mm in 10 rounds. In case of Latch Ram simulation, we will have electrical signals of ramp type (AIs) in the domain 0 - 5 V, with signal saturation at positioning on setpoint or at mechanical stop in described situations and digital signals at 0 and 24 V levels [5].

Generating of analogue/digital signals respects the algorithm described in Fig. 8.

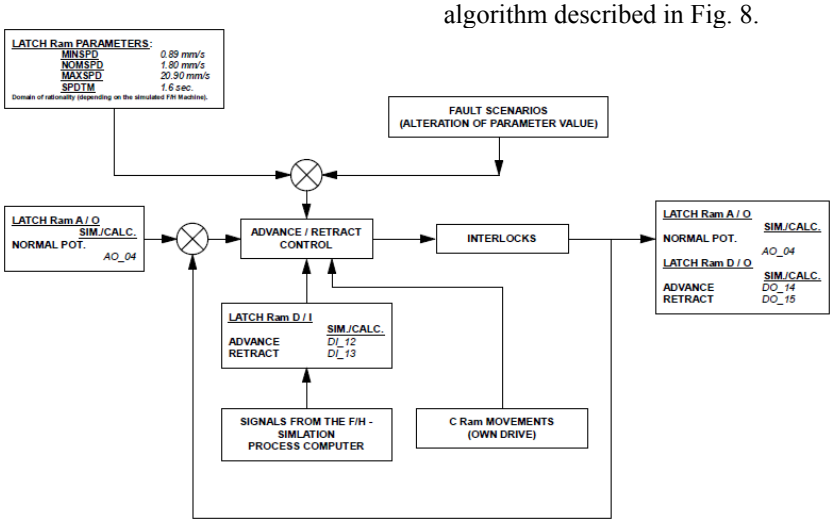


Fig.8. Simulation algorithm for Latch Ram signal

Simulation of Latch Ram semiautomatic mode operation

Control Latch movement and positioning to a given position [7]. The corresponding mnemonic (CLL*) is introduced using the alphanumeric keyboard.

If Latch Ram position < SETPOINT value corresponding to the position (ADVANCE) - check (see Fig. 9):

- DO_14 - SET, the direction of travel is advance;
- Loop program is running.



Fig.9. Latch Ram advance

If Latch Ram position > SETPOINT value corresponding to the position (RETRACT) - check (see Fig. 10):

- DO_15 - SET, the direction of travel is retract;
- Loop program is running.



Fig.10. Latch Ram retract

Projecting and implementing simulation algorithms for Magazine Pressure Control

F/H Magazine pressure control is performed by using the pneumatically operated PCV pressure control valve, which is located on the Magazine return line [6].

The controller receives an electrical signal setting the desired pressure conditions and a feedback signal from the PT pressure transducer mounted on the line pressure sensing line. This signal gives to controller a direct reaction of the magazine pressure and as a result, PCV valve will be operated in direct accordance with magazine pressure value.

Under normal conditions, the magazine supply line ensures a constant flow of 45 l/min by achieving a controlled pressure drop that amounts to 4.83 MPa, on the fixed value hydraulic impedance between the inlet to the valve station and inlet to the Fuel Handling Machine Head.

When F/H Machine works outside the reactor, the heavy water is returned to heavy water supply system via the storage return line through the PCV valve (the return pressure to the valve stations on the return line is approx. 0.69 MPa). When the machine is connected to the reactor, the heavy water passes into the high temperature heat transfer system via the reactor channel.

The experimental model provides the functional simulation for some of the automation devices involved by the pressure control system in the MID magazine (Fig. 11).

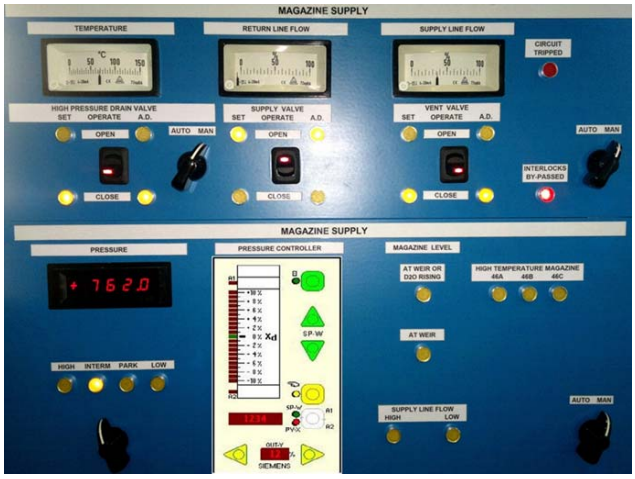


Fig.11. F/H Magazine Supply Simulation Consoles

Pressure Control Valve Modelling

The control element of the pressure in the magazine is represented by the PCV pneumatic valve, assembled on the magazine return circuit. The valve is supplied with electro-magnetic positioner receiving the signal from the PT pressure transducer. For damping pressure oscillations in F/M magazine, TK pressure accumulator is assembled upstream PCV valve. For initial setting of the maximum pressure level is using the SO hydraulic resistance by SV valve (see Fig.12).

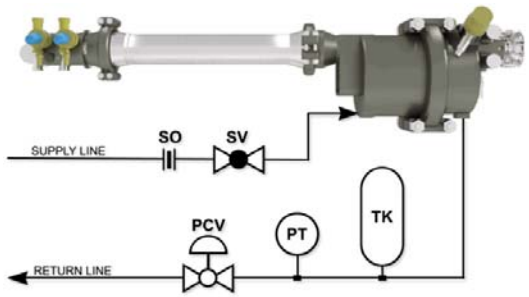


Fig.12. The control circuit of the pressure in F/M magazine

To determine the mathematical model of the control valve the following diagram is used:

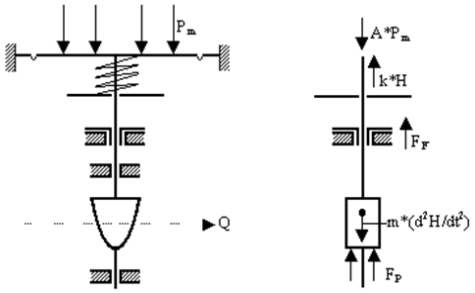


Fig.13. The pneumatic control valve

The forces calculation:

$$m\frac{d^2H}{dt^2}+\mu\frac{dH}{dt}+k\cdot H=A\cdot P_m-F_p \qquad (1)$$

with $k\cdot H=$ spring elastic force, $\mu\dfrac{dH}{dt}=F_F$ - friction force.

$$\frac{Q}{Q_{100}}=\frac{1}{\sqrt{1+\psi\left(\dfrac{1}{k_V^2}-1\right)}} \qquad (2)$$

By linearization around the point $H = H_0$ it results:

$$\frac{m}{k}\frac{d^2}{dt^2}(\Delta H)+\frac{\mu}{k}\frac{d}{dt}(\Delta H)+\Delta H=\frac{A}{k}\cdot\Delta P_m \qquad (3)$$

$$\Delta H=H-H_0 \qquad \Delta P_m=P_m-P_{m0} \qquad (4)$$

With $P=\left[\dfrac{d}{dk_V}\left(\dfrac{Q}{Q_{100}}\right)\dfrac{dk_V}{dH}\right]_{H=H_0}$, $q=\dfrac{Q}{Q_{100}}$, we can write:

$$\frac{m}{k}\frac{d^2}{dt^2}(\Delta q)+\frac{\mu}{k}\frac{d}{dt}(\Delta q)+\Delta q=\frac{A\cdot q}{k}\cdot\Delta P_m \qquad (5)$$

Applying the Laplace transformation to above differential Eq. (5) and developing the ratio $\dfrac{\Delta q(s)}{\Delta P_m(s)}$:

$$\frac{\Delta q(s)}{\Delta P_m(s)}=\frac{b}{a_2\cdot s^2+a_1\cdot s+1} \qquad (6)$$

so the transfer function of the PCV is:

$$G_{PCV}(s)=\frac{b}{a_2\cdot s^2+a_1\cdot s+1}=\frac{0.0852}{2.456\cdot s^2+1.25\cdot s+1} \qquad (7)$$

The notations/symbols used are: $b=\dfrac{A\cdot p}{k};a_1=\dfrac{\mu}{k};a_2=\dfrac{m}{k}$

with: m - mobile element mass; H - plug stroke;
k - spring elastic factor;
P_m - pressure on diaphragm; A - diaphragm section;
μ - viscous friction factor; q - flow rate;
Q - flow rate to any opening;
Q_{100} - flow rate to maximum opening.

The flow rate and the pressure can be related by considering the relation between the volumetric flow rate and the pressure drop: $Q = k_V \sqrt{\frac{\Delta P_r}{\rho}}$, where $k_V = f(\zeta, s)$ - specific flow factor, and ζ - specific leakage factor.

Using the simulation environment Matlab-Simulink, the simulation of the PCV control valve behaviour at step impulse is obtained (see Fig.14).

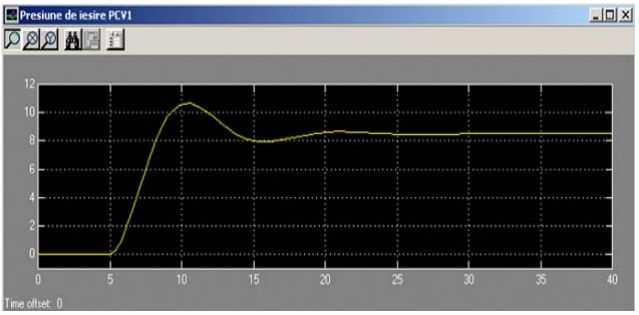


Fig.14. The PCV response at step impulse

Conclusions

The Fuelling Handling Machine is a system by which the nuclear reactor is periodically refuelled with fresh fuel, in order to continuously support the fission reactions and power generation. Well exploitation and proper operation of the system has influence, as consequence, on efficiency and safe operation of NPP, generally.

Performing a complete simulator of FHS from NPP is a point-full, efficient and advisable solution for completion of the control room F/M operator's training program in nuclear reactors.

MESI, the experimental simulator, is an instrument designed to set the requirements and fabrication details for SISMC simulator, especially for the software kit to be implement on it.

SISMC simulator consist of a number of control desks, identical to those from Cernavoda NPP reactor control room, where operators being in training will interact with the equipment, a trainer's console where the applications shall start and run, as well as the computing equipment providing the process modelling and simulated execution of the controls.

Using in the training program, or operator's testing, checking and evaluation of such instruments gives a lot of advantages, but the most important may be that to increase the training cycle quality and to allow the simulated testing in condition identical of the real case, of manual or automatic interventions in solving potential operation events of a technological installation.

As future plans, the Institute for Nuclear Research Pitesti, Romania, will be involved in realizing a simulator for Fuelling Handling System part dedicated to reactor control room, useful for operator's training program.

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