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Objectives of Experimental Validation of Mechanical Equipment for BN-1200 Reactor Plant

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Main Objectives for the Design of Reactor Plant Mechanical Equipment

- Provide competitiveness vs. the PWR reactor plants of the same power
- Reduce overall dimensions of the reactor plant
- Reduce the relative material consumption and the cost of the refueling system
- Optimize the reactor plant refueling scheme
- Ensure reliable and safe operation

BN-1200 Refueling Scheme

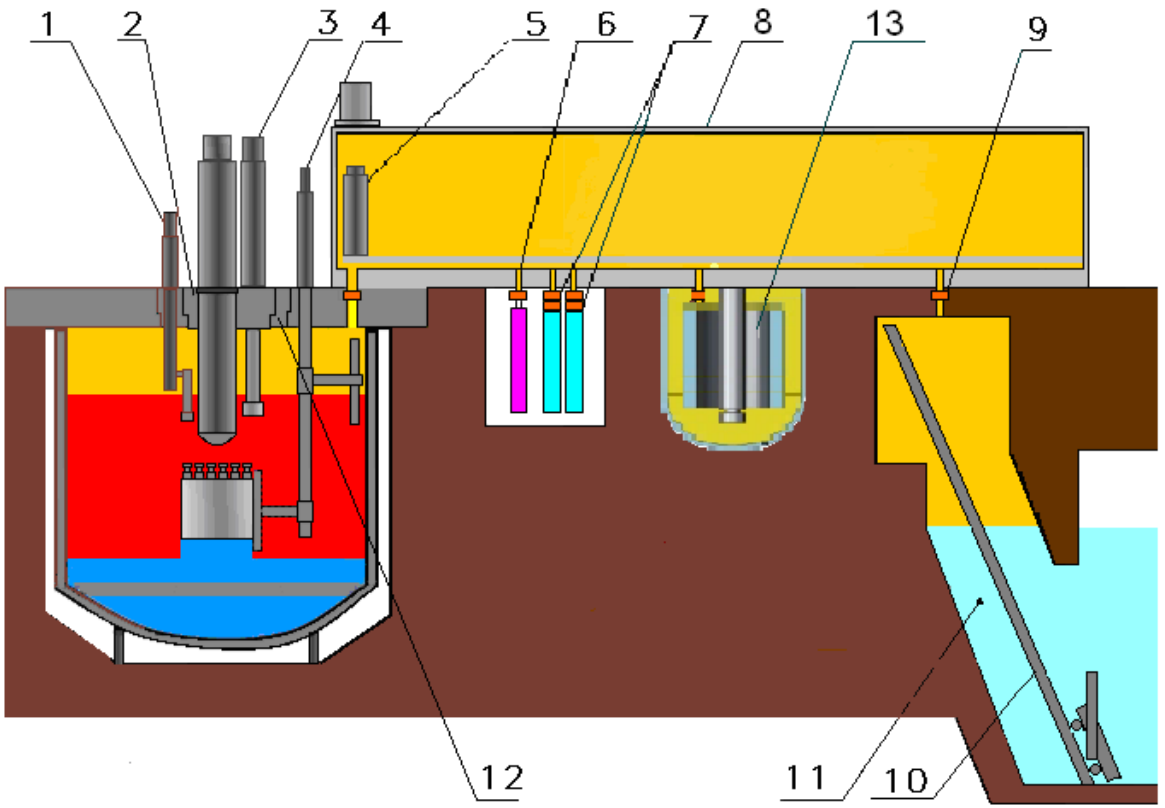


Fig.1

1. Cantilever refueling mechanism
2. Small rotating plug
3. Refueling mechanism
4. Elevator
5. Refueling machine
6. Lead-washing cell
7. Steam-and-water-washing cell
8. Refueling cell
9. Gate valve
10. Inclined hoist
11. Water pool
12. Large rotating plug
13. Fresh subassembly storage

BN-800 Refueling Scheme

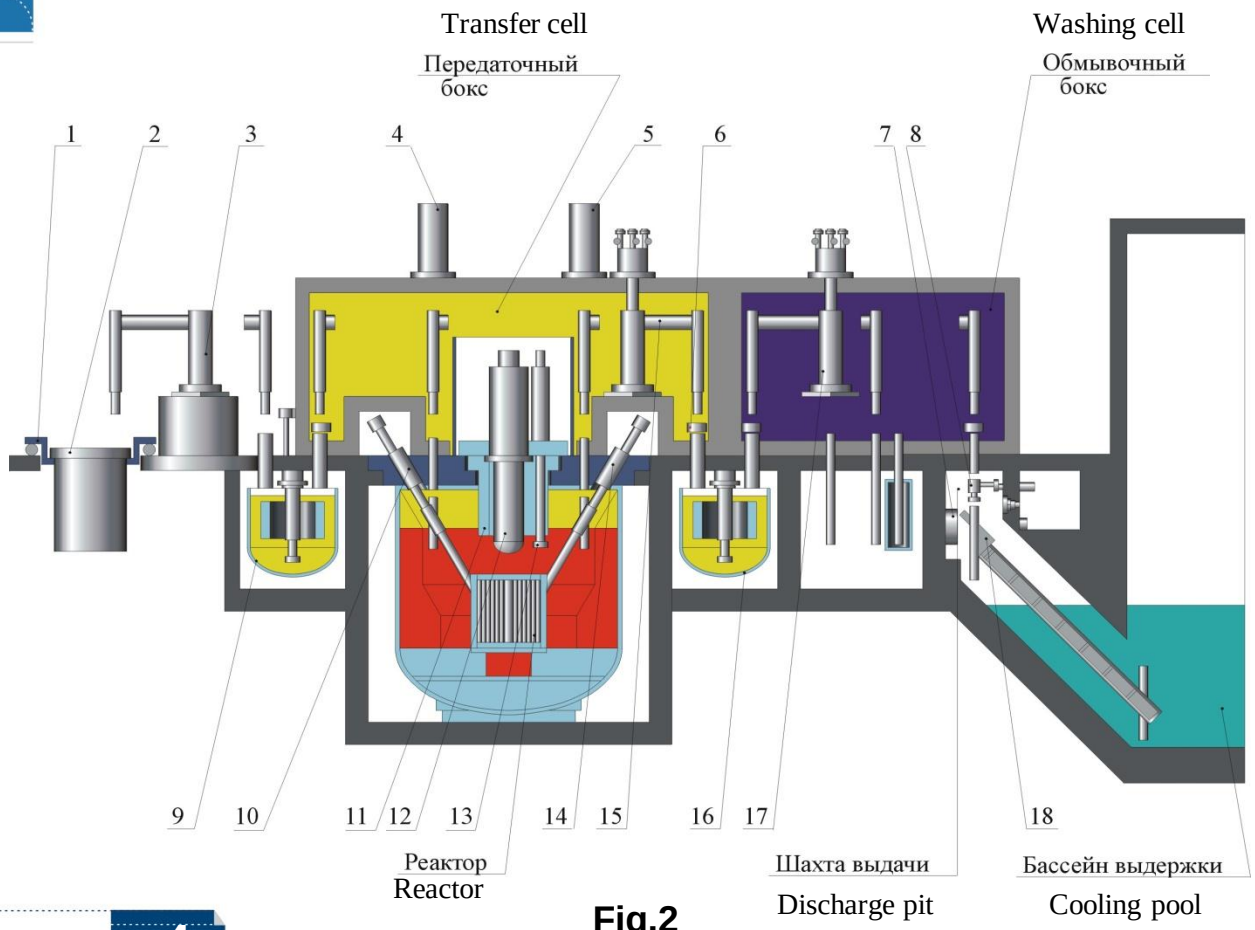


Fig.2

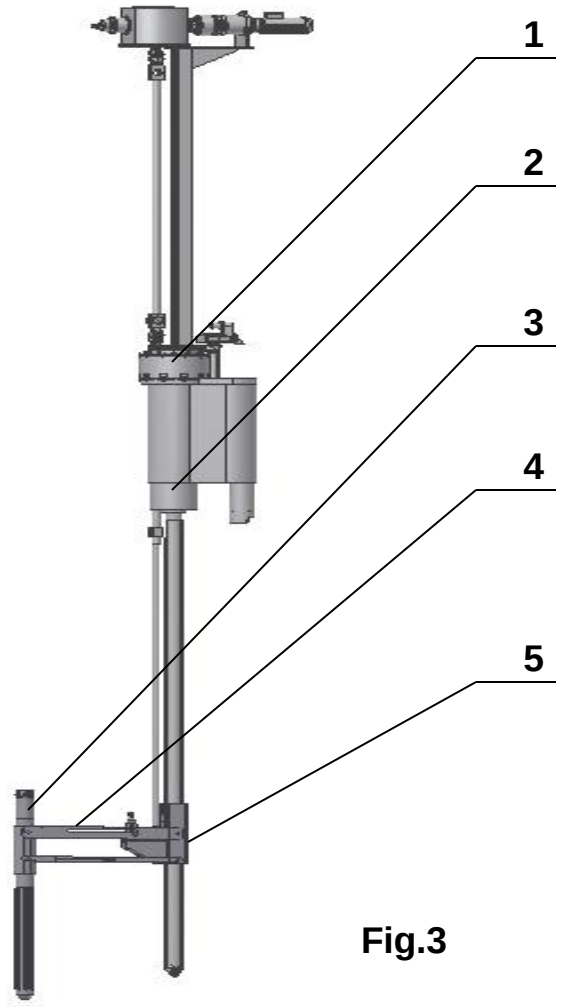
1. Rotating seat
2. Transport cask
3. Fresh assembly transfer mechanism
4. Loading elevator plug lifting mechanism
5. Unloading elevator plug lifting mechanism
6. Gas gate valve
7. Rotating furnace
8. Overpack sealing mechanism
9. Fresh subassembly storage
10. Loading elevator
11. Rotating plug
12. Central rotating column
13. Refueling mechanism
14. Unloading elevator
15. Fuel transfer cell mechanism
16. Spent subassembly storage
17. Fuel washing cell transfer mechanism
18. Inclined hoist

Main Engineering Solutions for the Reactor Internal Equipment Layout

Reactor	Rotating plugs	Refueling mechanism	Elevator	Cantilever mechanism	CRDM
BN-350	2	1	2 inclined	-	12
BN-600	2	2	2 inclined	-	27
BN-800	3	1	2 inclined	-	30
BN-1200	2	2	1 vertical	1	31

1 ELEVATOR DESIGN AND OPERATION

Main Design Solutions



1 – Rotating plug
2 – Mounting plug
3 – Sleeve
4 – Pantograph
5 – Carriage

Fig.3

Main Design Solutions

- Leak-tight elevator design
- Vertical guide
- The sleeve is attached to the carriage by the pantograph
- There is a pantograph folding mechanism
- The elevator is on the rotating plug that is in the mounting plug
- The mounting plug is secured in the reactor vessel
- The elevator is removed from the reactor vessel together with the mounting plug (Fig.4)

Main Design Solutions

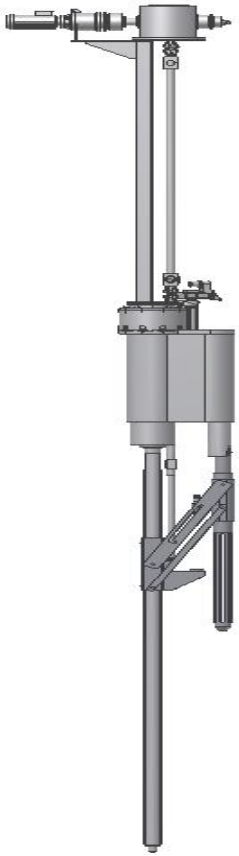


Fig.4

Elevator Operation Stages

- The carriage goes up from the bottom position to the top position
- The carriage turns around
- A subassembly is installed into the elevator sleeve
- The carriage turns around
- The carriage goes down

Proven Engineering Solutions in the Elevator Design

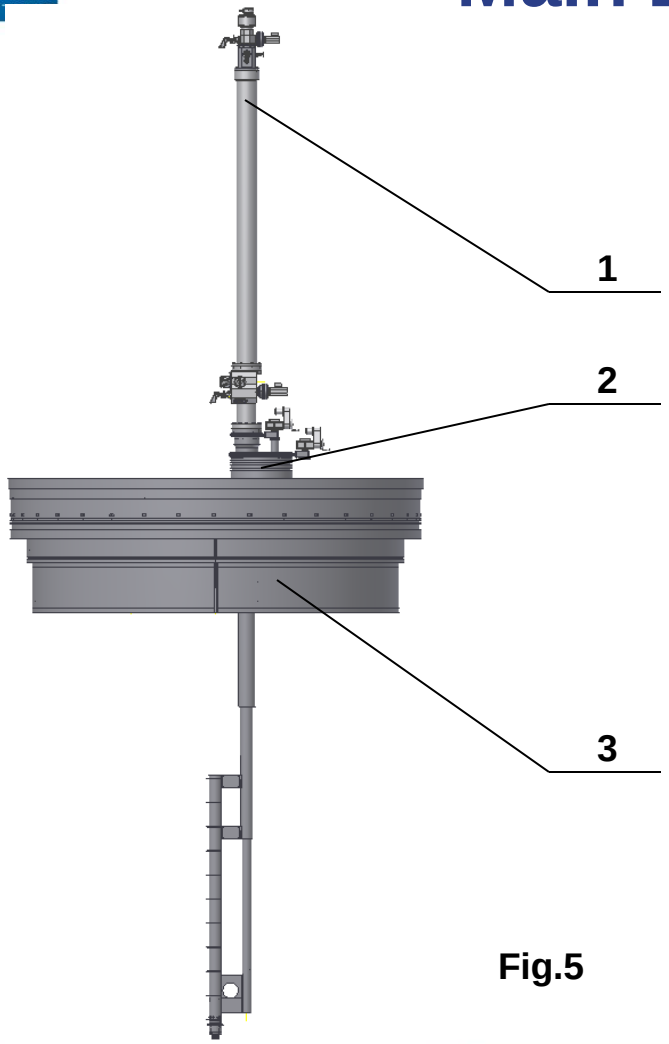
- Materials and design of the carriage slider
- Chain drive for the carriage
- Orientation of the subassembly in the sleeve
- Limitation of the force applied to the carriage
- Manual drive that backs up the elevator drive motor

Engineering Solutions that Require Experimental Validation

- Pantograph design
- Pantograph control drive design

2 CANTILEVER REFUELING MECHANISM

Main Design Solutions



1. Refueling mechanism
2. Mounting plug of the refueling mechanism
3. Large rotating plug

Fig.5

BN-1200 Rotating Plug Diagram

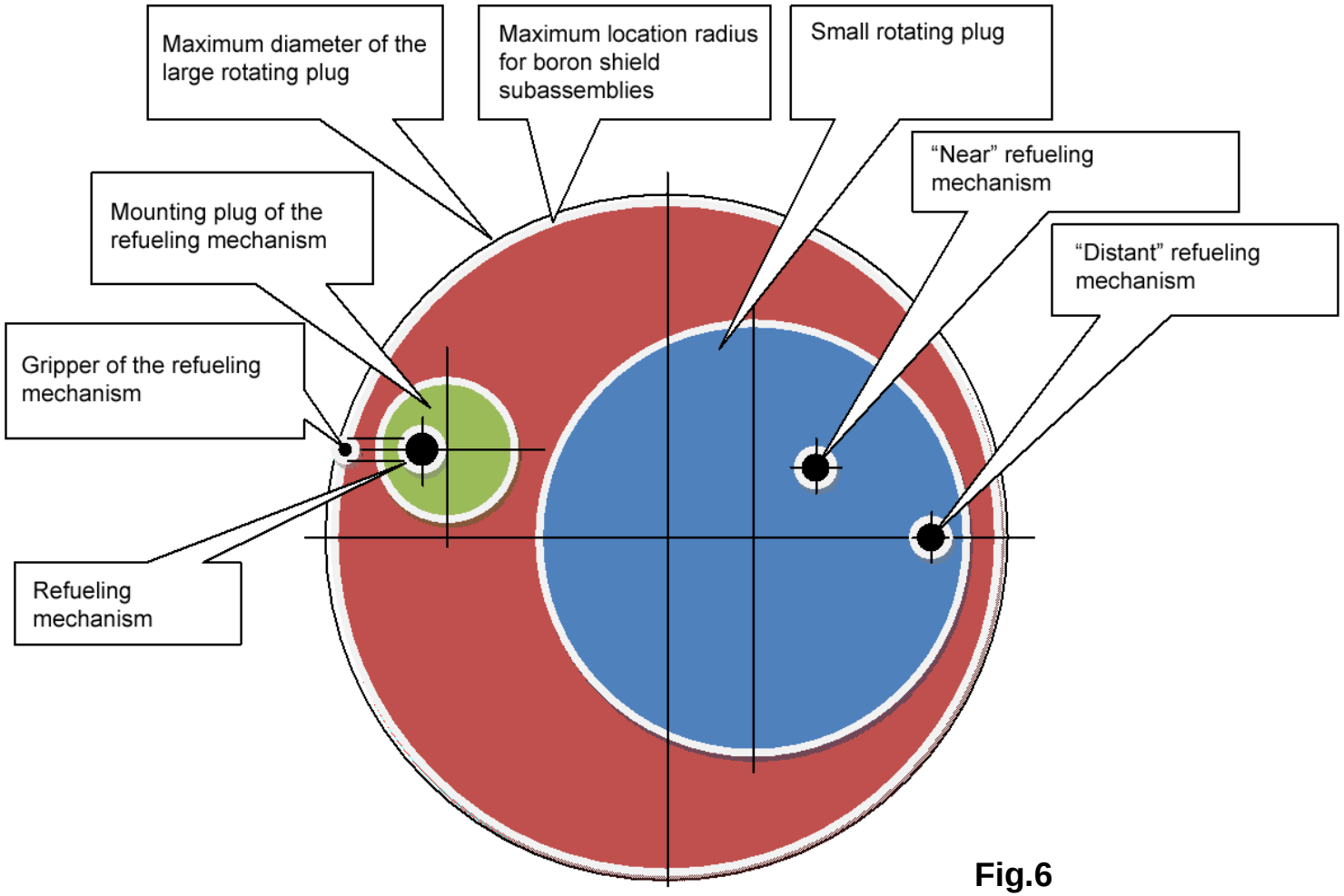


Fig.6

Main Design Solutions

- Leak-tight refueling mechanism
- Cantilevered design of the gripper
- Sensor unit aimed at subassembly extraction force monitoring developed based upon standard sensors
- Arrangement on the mounting rotating plug
- The refueling mechanism can turn relative to the mounting rotating plug
- The refueling mechanism is removed from the reactor together with the mounting rotating plug

Refueling Mechanism Operation Stages

- The gripper is brought to the respective cell in the reactor.
- The spent fuel subassembly is removed from the reactor cell.
- The gripper is brought to the elevator sleeve with orienting the facets of the spent fuel subassembly.
- The spent fuel subassembly is installed into the elevator sleeve.

Proven Engineering Solutions in the Refueling Mechanism Design

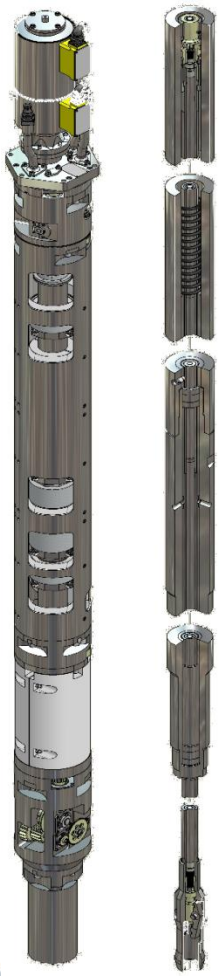
- The gripper is controlled through a guide pipe.
- Ball-screw drive is used in the gripper.
- The force is limited that is applied to the subassembly being unloaded.
- Manual drives back up electric motors in the refueling mechanism drives.

Engineering Solutions that Require Experimental Validation

- Cantilevered gripper operability under design loads
- Operability of the sensor unit aimed at subassembly extraction force monitoring

3 CONTROL ROD DRIVE MECHANISMS (CRDM)

Main Design Solutions



Shim rod drive mechanism

Safety rod drive mechanism

Control rod drive mechanism

Main Design Solutions

- The control rod moves coaxially with respect to the longitudinal axis of the CRDM.
- An electromagnetic coupling is used in the CRDM to ensure fast insertion of the control rod into the core.
- The CRDM is leak-tight.

CRDM Operation Stages

- CRDM is engaged to the control rod after reactor refueling.
- The control rod is lifted to the specified elevation.
- The control rod moves during power operation of the reactor.
- The CRDM is disengaged from the control rod before reactor refueling.

Proven Engineering Solutions in the CRDM Design

- Self-braking worm gears and stepping motors
- Lifting the control rod by a rack-and-pinion drive
- Manual drives that back up electric motors in drives

Engineering Solutions that Require Experimental Validation

- High-power motors in the control rod drives
- Reinforced elements in the kinematic chain of control rod drives

Conclusion

- **Fabricating and testing the pilot specimens of CRDMs, mockups of main elevator units, and cantilever refueling mechanism make it possible to validate their design.**
- **Positive testing results will make it possible to start the work on developing:**
  - **final designs of the elevator and cantilever refueling mechanism**
  - **manufacturing design documentation on CRDM prototypes**