This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission."

# Parameter study and dynamic Simulation of current DEMO Intermediate Heat Transfer and Storage System design via MATLAB/Simulink

**M.-V. Bologa, R. Stieglitz, W. Hering, E. Bubelis**

Karlsruhe Institute of Technology (KIT), Institute for Neutron Physics and Reactor Technology (INR)
76344 Eggenstein-Leopoldshafen, Germany

## Introduction

**State:**

- ✓ Nuclear fusion is expected to offer limitless fuel reserves
- ✓ Steady energy supply needs development of effective technical solutions
- ✓ For the DEMOstration Fusion Power Plant (DEMO FPP) an Intermediate Heat Transport and Storage System (IHTS) is developed
- ✓ The HITEC molten salt is proposed to be used as a heat transfer fluid in the IHTS two-tank direct system

**Scope:**

**Study of parameters and simulation of dynamic model for intermediate heat transfer and storage system (IHTS) via MATLAB/Simulink**

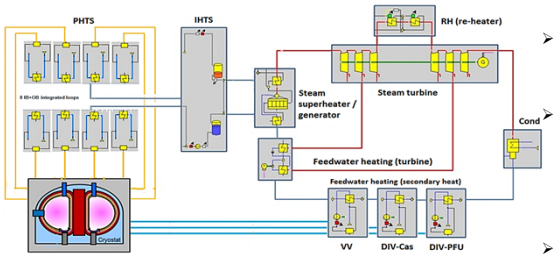
**Tasks:**

- ➢ Evaluation of dynamic behavior of DEMO-IHTS through the simulation via MATLAB/Simulink
- ➢ Calculation of thermodynamic parameters of HITEC molten salt and their involvement into the dynamic IHTS model via MATLAB/Simulink
- ➢ In due course simulation of temperature decay inside the hot and cold IHTS tanks and calculation of the tanks filling level during the Tokamak burn and dwell phases

## DEMOnstration Fusion Power Plant

**DEMO Balance of Plant (BoP) 2019 concept**

- ➢ **Design:** Helium Cooled Pebble Bed Breeding Blanket
- ➢ **Steady state conditions:** Thermal power of ~2 GW generated in 8 inner and outer breeding loops during pulse operation of DEMO FPP with 100% power transfer
- ➢ **Gross electrical power value:** ~ 987 MW

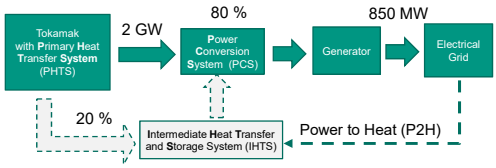



**Conceptual State of Balance of Plant (BoP)**

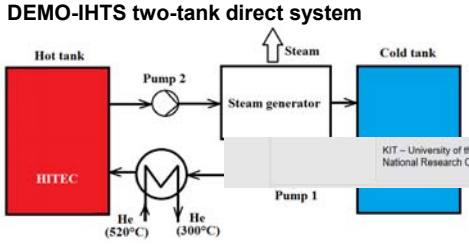
- ➢ **Pulsed operation:** burn phase of 120 min and dwell time of 10 min for dust/ash cleaning and loading of central solenoid
- ➢ **Intermediate Heat Transfer and Storage System (IHTS):** Coupling of Primary Heat Transfer System (PHTS) and Power Conversion System (PCS) with a two-tanks direct thermal storage
- ➢ **HITEC molten salt:** as heat transfer fluid for IHTS

## Intermediate Heat Transfer and Storage System Model (IHTS)

**Energy Transfer Chain for DEMO FPP**




**DEMO-IHTS two-tank direct system**



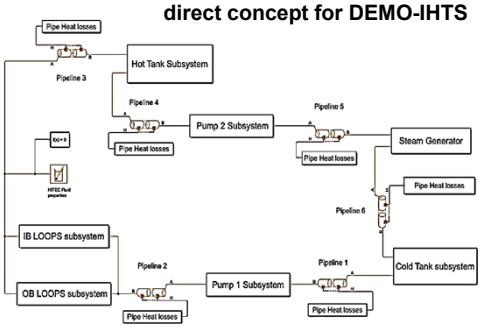

**IHTS**

- ➢ IHTS is coupled to PHTS, PCS and infrastructure
- ➢ It receives thermal energy from PHTS Inner Blanket and Outer Blanket loops
- ➢ Bounded critical temperature: 473.15 K to avoid HITEC molten salt crystallization

**HITEC molten salt parameters**

| Specification | HITEC molten salt |
|---|---|
| Composition | 7% $NaNO_3$, 53% $KNO_3$, 40% $NaNO_2$ |
| Min/Max. Temperature | 142°C / 535°C |
| Total mass of salt per tank | 5040 t |
| Size / Volume | Ø: 23.8m / H: 7.8m / V: 3000m³ |
| temperature | |
| Operational pressure | 1.0 bar – 2.0 bar |

**Dynamic model for two-tank direct concept for DEMO-IHTS**




Dynamic Simulation using MATLAB/Simulink to improve the Current ... Design, J.Oliveira, Master thesis, INR, KIT, 2018

✓ use same design blocks
✓ Simulation includes regulation of volume, tank level, temperature, height & heat losses

KIT – University of the State of Baden-Wuerttemberg and National Research Center of the Helmholtz Association
14th International Symposium on Fusion Nuclear Technology
September 22 – 27, 2019, Budapest, Hungary
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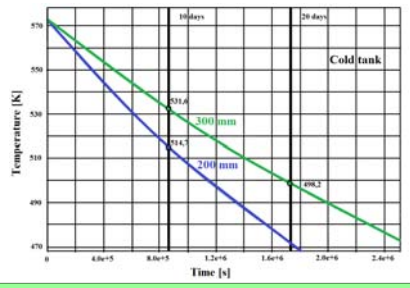
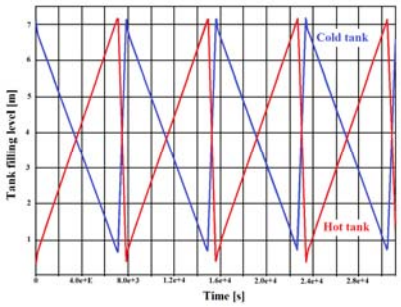
## Results of dynamic simulation

**Influence of thermo-insulation thickness on temperature of HITEC during stand-by**



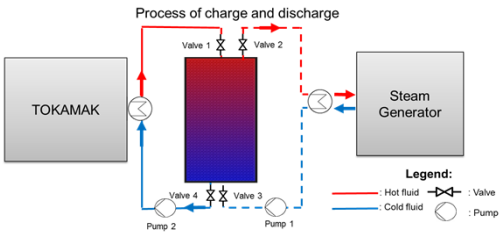

- ➢ During stand-by operation, no trace heating in DEMO-IHTS tanks is required
- ➢ For cold tank, with the insulation thickness of 200 mm and 300 mm, it takes for HITEC molten salt 20 and 30 days to reach the critical temperature of 473.15 K
- ➢ For hot tank it takes 27 and 40 days, correspondingly

**Filling level of IHTS hot and cold tanks for 4 fuel cycles**




- ➢ During pulse time, molten salt level in tanks changes in gradual way
- ➢ During dwell time, the change takes place in a steep slope

**Single tank thermocline DEMO-IHTS concept**




Dynamic Simulation of single-tank thermocline storage system using MATLAB/SIMULINK, C. Pasquet, international internship, INR, KIT, 2019

Single thermocline tank design concept:

- ✓ Lower costs in comparison with two-tank concept
- ✓ Less material and construction elements demand
- ✓ Reduced volume of heat transfer fluid
- ✓ Enhanced pumping system

## Conclusions

- ✓ Successful development of the dynamic simulation of DEMO-IHTS design
- ✓ Use of HITEC molten salt as heat transfer fluid
- ✓ First results of simulation with dynamic two-tanks IHTS model

## Acknowledgement

The authors thanks a lot the master students Joel Oliveira and Césaire Pasquet for their engagement and fruitful cooperation dedicated to the dynamic modelling of DEMO Intermediate Heat Transfer and Storage System