Tue-Af-Po2.03 - [31]

DYNAMICAL CRYODISTRIBUTION MODEL OF THE JT-60SA TOROIDAL FIELD COIL IN COLD TEST FACILITY

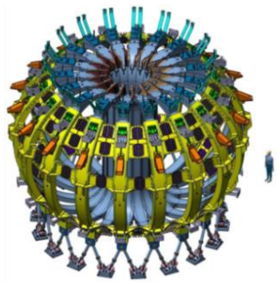
François BONNE[1], Walid ABDEL MAKSOUD[2], Daniel CIAZYNSKI[3], Benoit LACROIX[3], Christine HOA[1], Sylvie NICOLLET[3], Quentin LE COZ[3]

(1) CEA, INAC F-38000 Grenoble - (2) CEA, IRFU, F-91191 Gif-sur-Yvette - (3) CEA, IRFM, F-13108 Saint Paul-lez-Durance // France

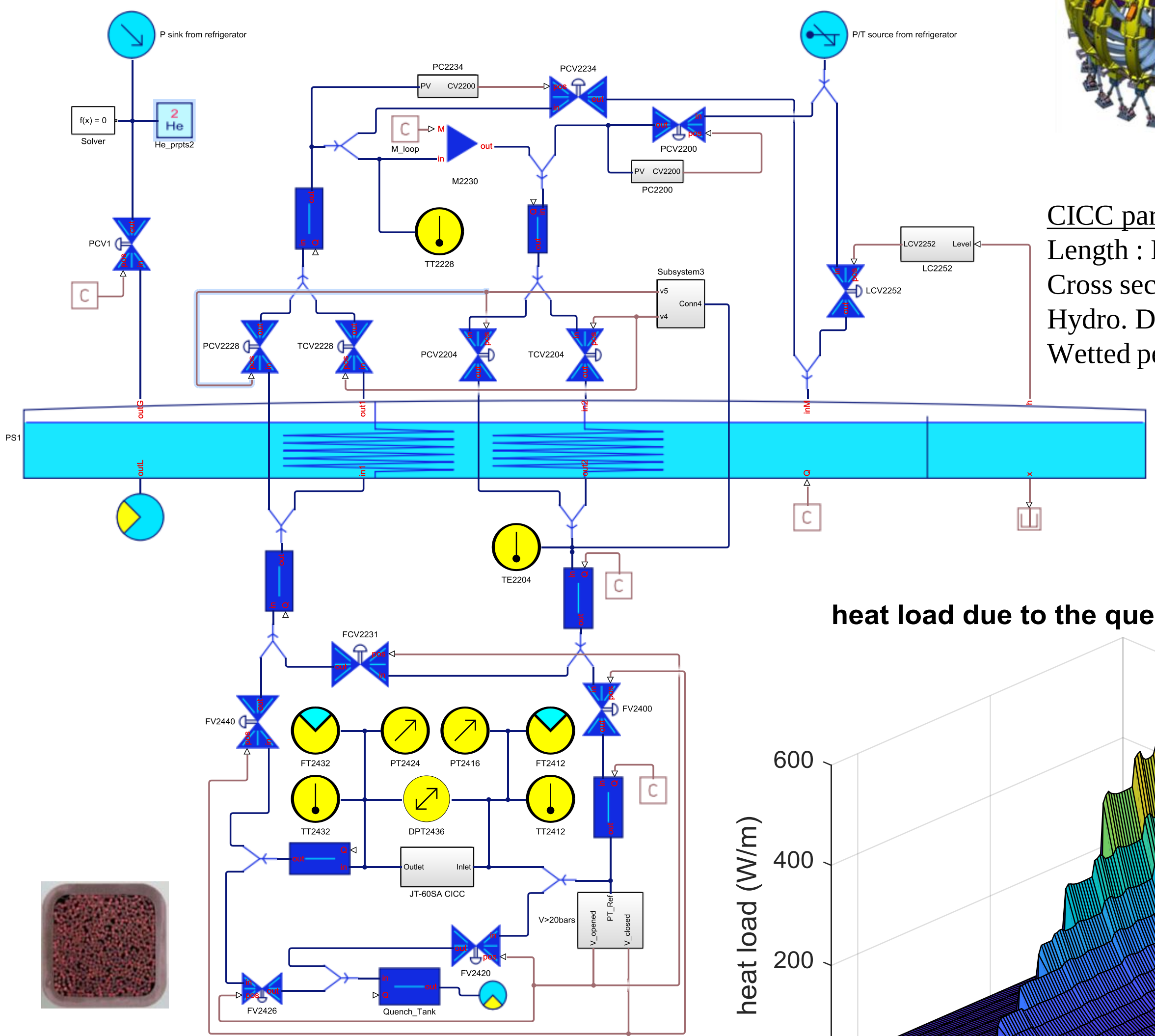
Introduction

- TF system of JT-60SA : 18 NbTi Coils with 6 CICC wound in 6 Double-Pancakes
- I = 25.7 kA , Top= 4.7 K, Energy=1.1 GJ (Tokamak system), Quench detection: DV=0.1 V with t_{delay}= 0.1 s.
- Coils produced by ASG (Italy) and GE (France) and tested in Cold Test Facility (CTF, CEA Saclay).
- Test program : DC operation (one hour) and progressive increase of inlet helium temperature up to quench.
- Twelve coils tested → similar results of quench inlet temperature (7.5 K)/ different locations (lateral/central).

- **This poster presents the thermohydraulics model of the cryodistribution and the CICC, with the MATLAB environment Simcryogenics up to and after the quench**.

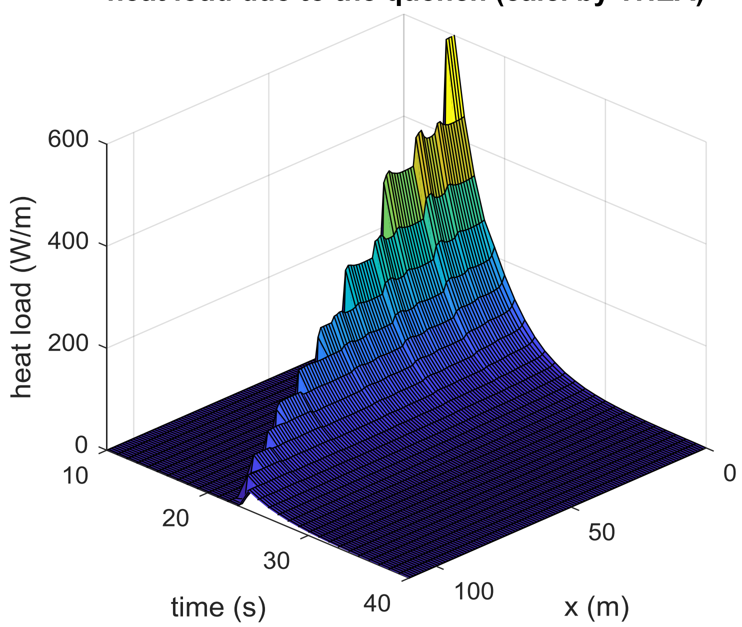


JT-60SA TF Coil Model with the Simcryogenics code



CICC parameters
Length : L = 113m
Cross section : S = 125.824e-6 m^2
Hydro. Diam. : Dh = 0.45423e-3 m
Wetted perimeter : Pw = 1.1080 m

heat load due to the quench (calc. by THEA)



CICC modelling

State model

3 states for each control volume : density ρ, specific internal energy u and associated mass temperature T of the CICC (St.Steel., NbTi,Cu)

$$\dot{u}_i = \frac{M_{i-1}H_{i-1} - M_i H_i + Q - u(M_{i-1} - M_i)}{\rho V}$$

$$\dot{\rho}_i = \frac{M_{i-1} - M_i}{V} \qquad \dot{T}_i = \frac{\Sigma Q}{\Sigma Mass \cdot Cp}$$

Algebraic equations to calculate the flowrate between control volumes

$f = 0.0945 + 36.16 * Re$^-0.75 // Friction factor

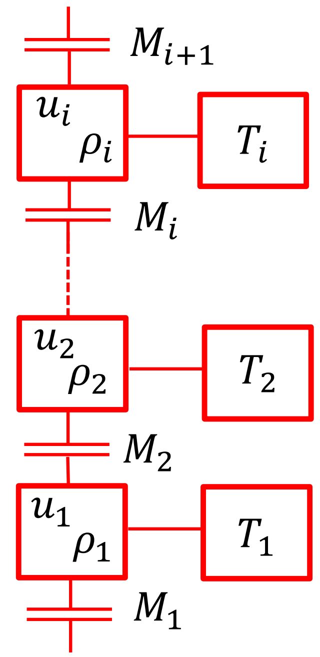
$Re = {}^{4\cdot|M|}/_{\mu \cdot Pm}$ // Reynolds number

$h = \frac{f \cdot \lambda \cdot Re \cdot Pr^{1/3}}{8 \cdot Dh}$ // heat exchange coefficient between the fluid and the mass

$sign(\Delta p) \cdot M^2 = \frac{|\Delta p| \cdot 8 \cdot \rho \cdot S^3}{f \cdot L \cdot P_w}$ // flowrate

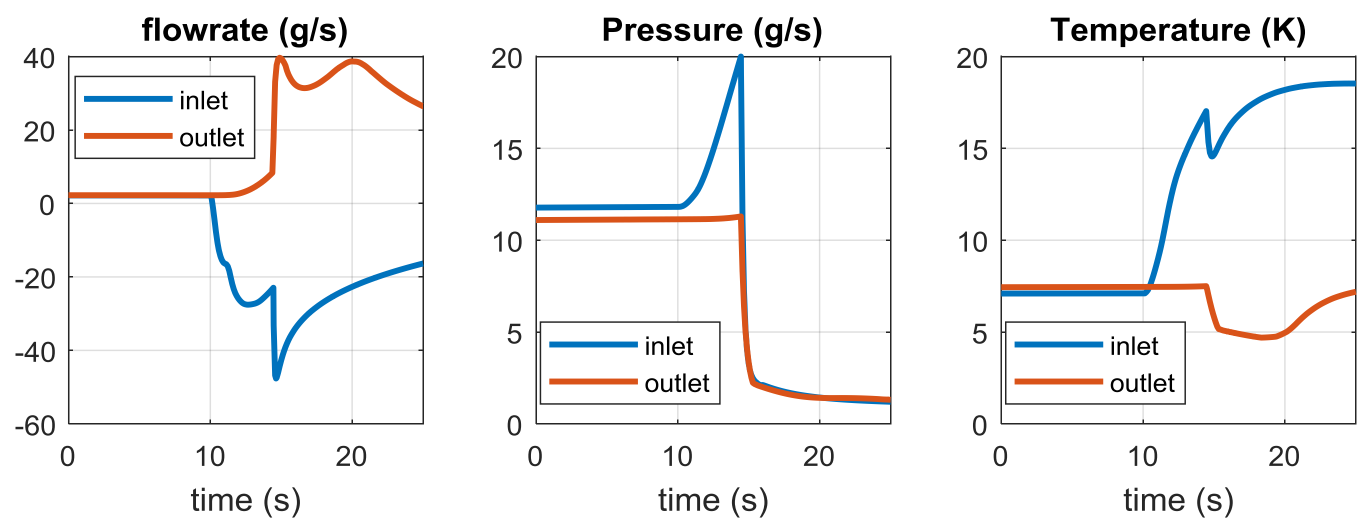
$\Delta p = p_i - p_{i-1}$ // pressure difference

Helium properties, such as pressure, viscosity, conductivity and Prandtl number are calculated with state variable u and ρ with Hepak



Results

At t = 10s, the superconductor is quenching. At p = 20 bars, the CICC is isolated with the isolation valves and the helium flow is driven to the quench tank. All plot are the variables at the inlet and the outlet of the CICC



Conclusion

- The **Simcryogenics code for MATLAB / Simulink / Simscape** has been used to simulate the dynamical behavior of a cryodistribution system associated to a **CICC, up to and after the quench**
- **The code shown reverse flow capabilities**

Perspective

These features could be used to:
- **Test and enhance safety procedure**
- **Test and enhance quench detection techniques**
- **Design safety organs**