Electromagnetic Analysis of Transient Disruption Forces on the ITER Shield Modules

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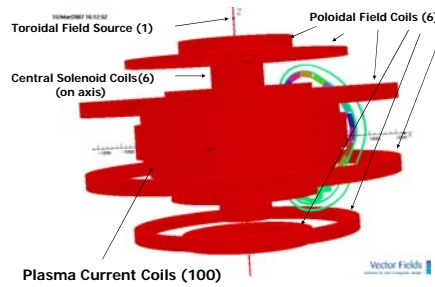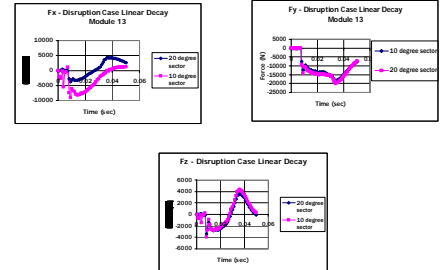Dept. 1652

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Objectives

- Predict forces on different modules due to the interaction of the disruption of the plasma currents and the toroidal/poloidal magnetic fields.

- These forces are then passed on for the computation of stresses and torques on the different modules.

Analysis Method

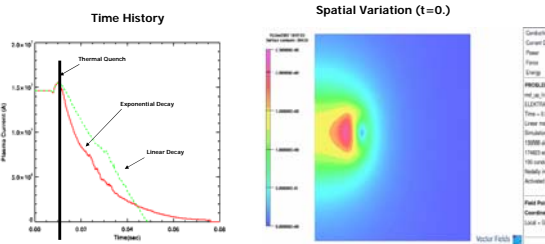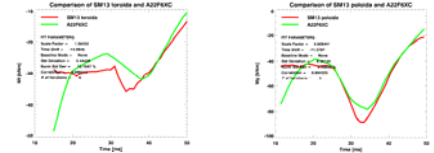- Commercial code Opera-3d is the tool of choice on a 64-bit Linux platform.

- 3-D electromagnetic solver that can be used to calculate Eddy currents and forces.

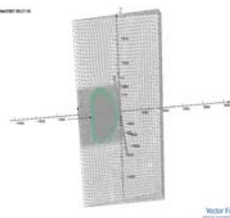- Ability to use symmetry and also output the forces on user supplied grids.

Analysis Procedure

- Generate Solid Model
  Simplified for EM Analysis
  Three models
    US only - modules 6-7-8 (20 degree sector)
    US only - modules 11-14 (20 degree sector)
    Complete 1-18 modules (10 degree sector)

- Apply the excitations
  Use DINA data to create equivalent sources
    Originally 4 different disruption cases

- Generate Mesh
  Using the Opera software
  Symmetry is used

Module Simplification

Solid Models

Shield Module 8
Shield Module 7
Shield Module 7
Shield Module 6

Shield Module 7
Shield Module 13
Shield Module 1
Shield Module 18

Disruption Currents/ DC Field Modeling

Toroidal Field Source (1)
Poloidal Field Coils (6)
Central Solenoid Coils(6) (on axis)
Plasma Current Coils (100)

Time History

Spatial Variation (t=0.)

Thermal Quench
Exponential Decay
Linear Decay

Mesh Description

Sector (Degrees)	Modules	Element Count
10	1 through 18	~3 million
20	6-7-8	~3.6 million
20	11-12-13-14	~4.6 million

Eddy Currents

Force Comparisons Module 7
(10 and 20 degree model)

Fx - Disruption Case Linear Decay Module 7
Fy - Disruption Case Linear Decay Module 7
Fz - Disruption Case Linear Decay Module 7

Force Comparisons Module 13
(10 and 20 degree model)

Fx - Disruption Case Linear Decay Module 13
Fy - Disruption Case Linear Decay Module 13
Fz - Disruption Case Linear Decay

Torque Comparisons Module 13
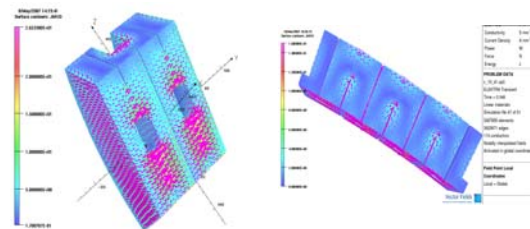### (10 degree model, Japanese Results)

Conclusions

- The computation of Eddy currents and the resulting forces on a module has been demonstrated.

- Calculation of forces for certain shield modules and disruption cases show major differences between 10 and 20 degree models.

- Compared to Japanese results – some discrepancies need to be resolved.
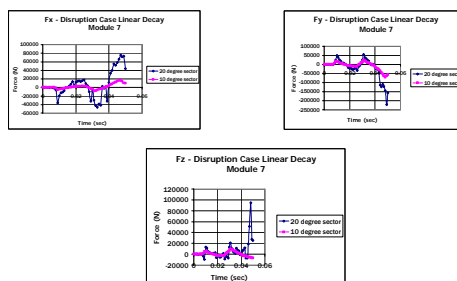
Continuing Work

- Examine higher fidelity models to assess the effect of the cooling holes and first wall structure.

- Incorporate the Halo currents to the simulation. Also simulate additional disruption scenarios as they are defined.

- Resolve differences found with Japanese analysis.

- Calculate forces on finite element mesh needed for stress calculations.