Structural Design of Limiter and Divertor for Aditya Tokamak Upgrade

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Introduction

Existing Aditya tokamak with limiter configuration is being upgraded into a machine to have both the limiter and divertor configurations. Limiter and divertor structures for Aditya tokamak upgrade are designed based on numerical simulation of the plasma equilibrium profile. Aditya tokamak upgrade will have different set of limiters and divertors, i.e.

(1) Safety limiter,

(2) Toroidal Inner limiter,

(3) Toroidal outer limiter,

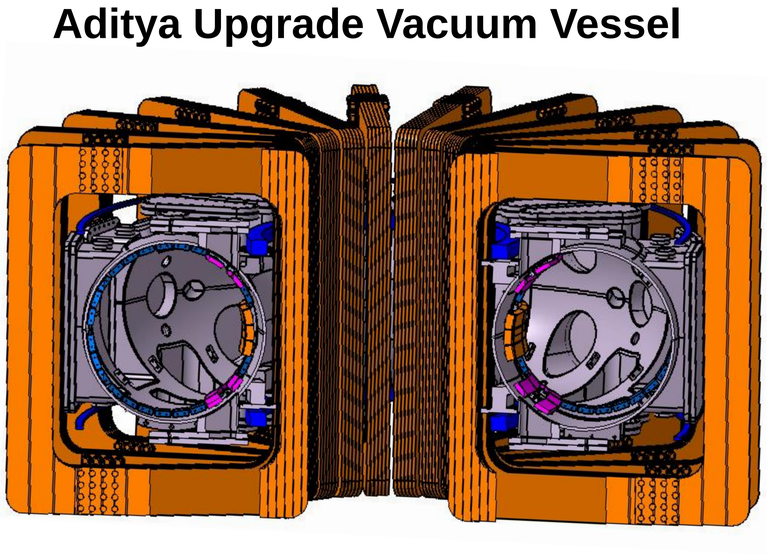
(4) Upper and Lower divertor plates.

Initially fusion grade graphite IG-430 [1] will be used as plasma facing material (PFM) in all the limiter and divertor plates. These PFMs are subjected to very high heat flux during high temperature long duration plasma discharges. In Aditya Upgrade, PFMs are required to withstand ~ 1 MW heat load in extreme condition during pulsed plasma operation. Depending upon the above mentioned heat loads; the thickness of graphite tiles for limiter and divertor plates is estimated. Shaped graphite tiles will be fixed on specially designed support structures made out of SS 304L inside the torus shaped vacuum vessel.

Aditya Upgraded divertor configuration

- To provide better performance, Aditya is upgraded from circular plasma to X-point plasma.
- Old BV1, BV2 coils have to be fed independently
- D1 & D2 are two pairs of poloidal field coils (divertor Coils) with current limit 150 kA
- Divertor coils are positioned at Available Space
- Rectangular vessel is converted into circular vessel with diameter of 61 cm

Aditya Upgrade Vacuum Vessel



Circular vacuum vessel with diameter 61 cm [3].

Minor Radius	: 0.25 m
Major Radius	: 0.75 m
Base Pressure	: ~ 1 X 10^{-9} torr
Fuel Gas	: Hydrogen
Fill Pressure	: ~ 1 X 10^{-4} mbar
Total Volume	: 1.5 m^3
Surface Area	: 10 m^2
Pumping System	: Four UHV Lines with two Turbo Molecular Pumps & Two Cryo-pumps, Additional ports to add more pump

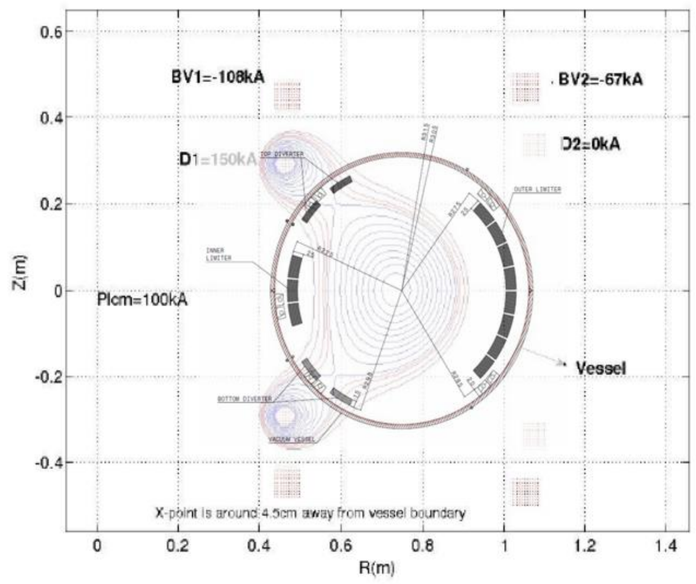
Plasma parameter for upgradation

Plasma Current	: 75 to 150 KA
Plasma Duration	: 80 to 250 ms
Plasma Density	: ~ 2 X 10^{19} m^{-3}
Plasma Temperature	: ~ 350 – 500 eV
B_{tor}	: 1.5 T

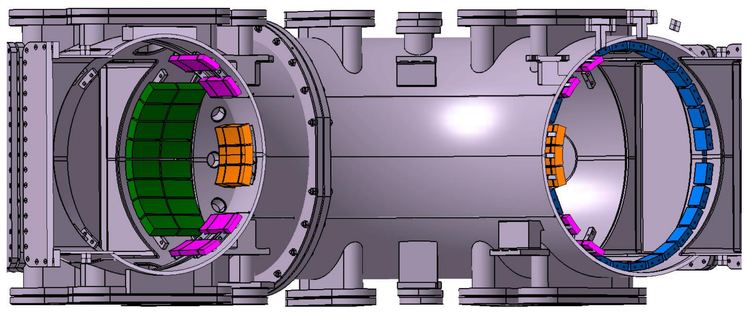
Divertor Plasma vs Limiter Plasma

- Role of Both divertor and limiter plasma is to prevent plasma wall surface intraction.
- Divertor Plasma is better than limiter plasma as defined below.
  - ❖ Reduce impurity content
  - ❖ Improve the heat removal capacity
  - ❖ Achieve much higher temperature in core

Equilibrium Construction

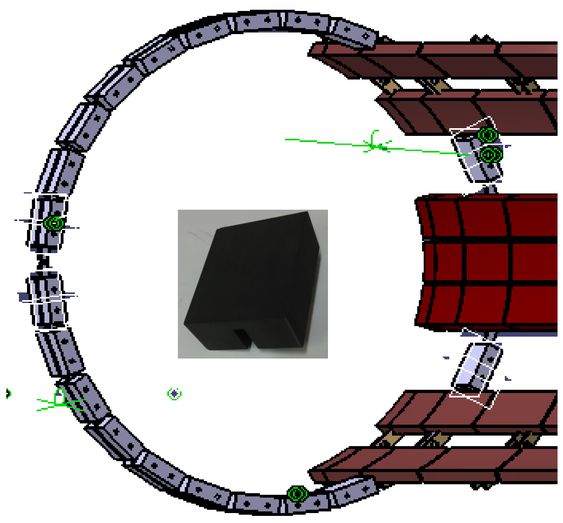


Limiters and Divertors for Aditya

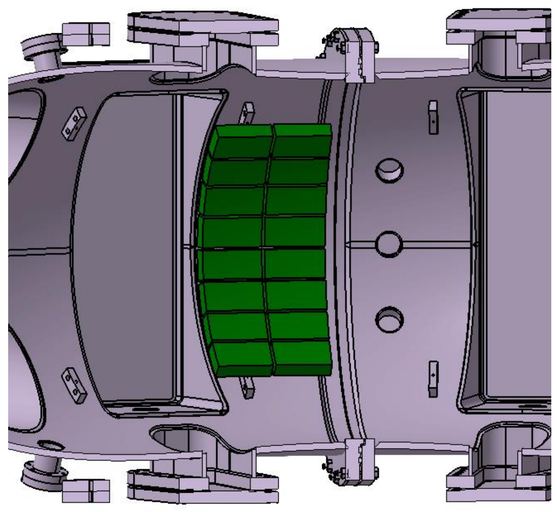


- Electropolished support structure made out of SS 304L
- Fusion grade high purity isostatically pressed graphite IG-430 tiles will be used as Plasma Facing Material.
- UHV compatible material

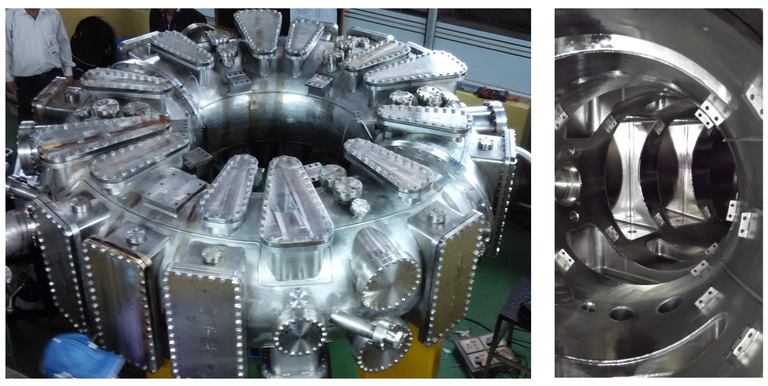
Safety Limiter



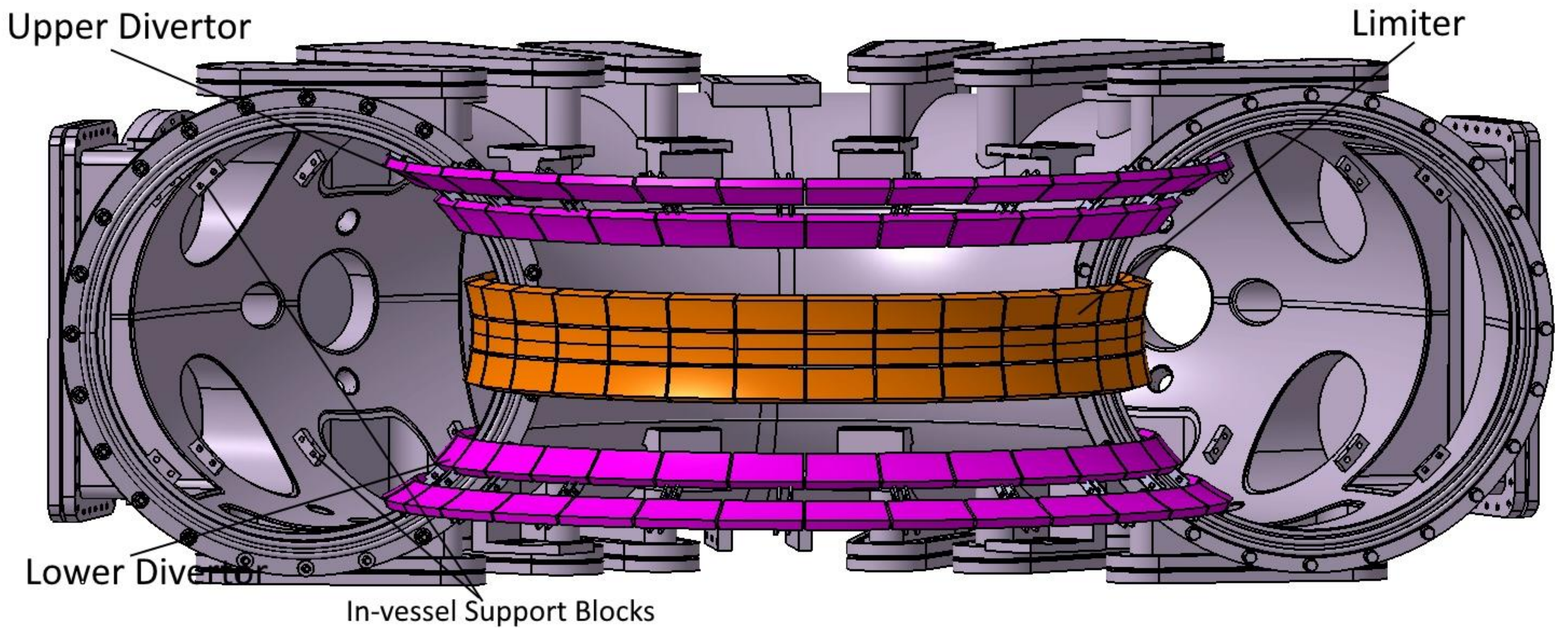
Toroidal Outer Limiter



Present status



Toroidal Inner Limiter & Divertor with Vacuum vessel



Conclusion

- Upper & Lower divertor structures are identically designed.
- Integration of safety limiter with divertor & Limiter structure is performed in such a way both can act independent.
- Integration of limiter and divertor with in-vessel diagnostics are on going.

Reference

[1]http://www.toyotanso.co.jp/Products/application/atomic-nuclear_en.html

[2] S. B. Bhatt, D. Bora, et al., Indian Journal of Pure and Applied Physics, 27(1989)710

[2] “Design of Vacuum Vessel for Aditya Upgrade Tokamak”, S. B. Bhatt, et al. XXVI Int. Symp. on Discharge and Electrical Insulation in Vacuum, Mumbai, India-2014,

National Symposium on Vacuum Technology and its Application to Electron Beams (IVSNS -2015), TIFR, Mumbai - 400005

Category: **Vacuum Based Plasma Devices (C6),** Poster ID: **053,**

Title: **Structural desing of Limiter and Divertor for Aditya Tokamak Upgrade**

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