Breeding in Flibe and Flinabe and the Requid Margin in TBR

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Outlines

- **Review the potential of Flinabe for breeding with comparison to breeding potential in Flibe – CliFF design (some results were discussed during last e-meeting 8-7-01).**

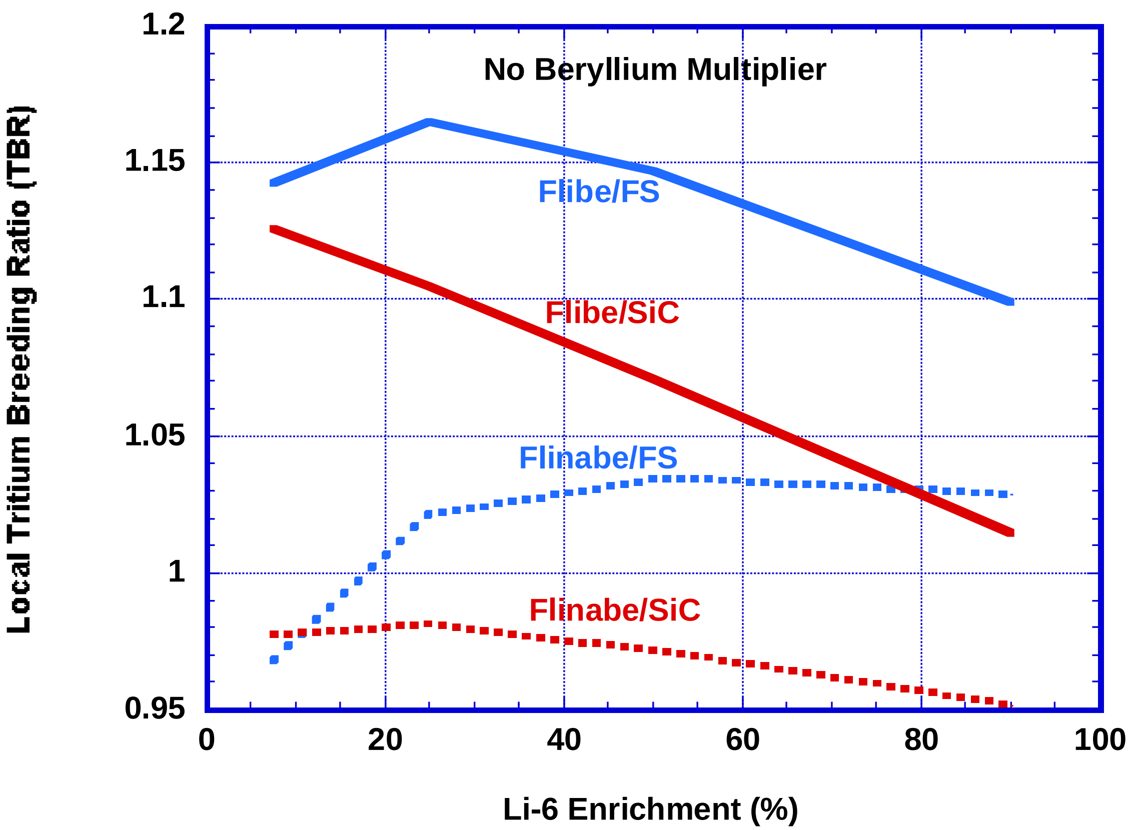
- **Discuss the requird margin in TBR to cover all possible uncertainties in performance parameters and computational tools**

- **Blanket: 60 cm thick (O/B), 40 cm thick (I/B). (2cm flowing liquid layer) in ARIES-RS Configuration**
- **Two types of structure are considered:**

  Ferritic Steel and SiC

- **Flinabe: LiF:NaF:BeF2 ratio 1:1:1, Flibe: LiF:BeF2 with ratio 2:1**

TBR Comparison with FS and SiC (No Be)



- **Beryllium multiplier is needed in both breeders to enhance TBR.**

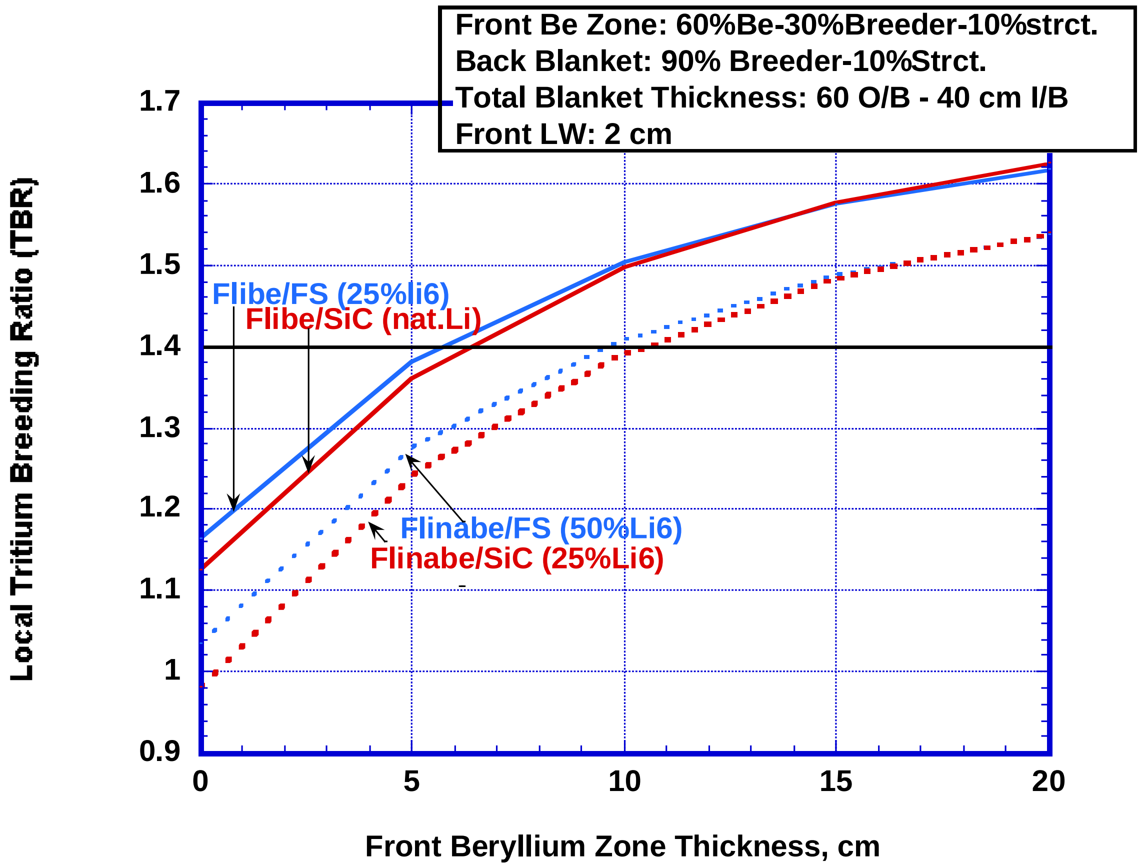
Ferritic Steel Structure

- TBR in Flinabe is less than in Flibe:
  - by ~15% (natural Li)
  - by ~6% (90% Li-6)
- TBR maximizes at:
  - Flinabe : ~50% Li-6.
  - Flibe: ~25% Li-6

SiC Structure

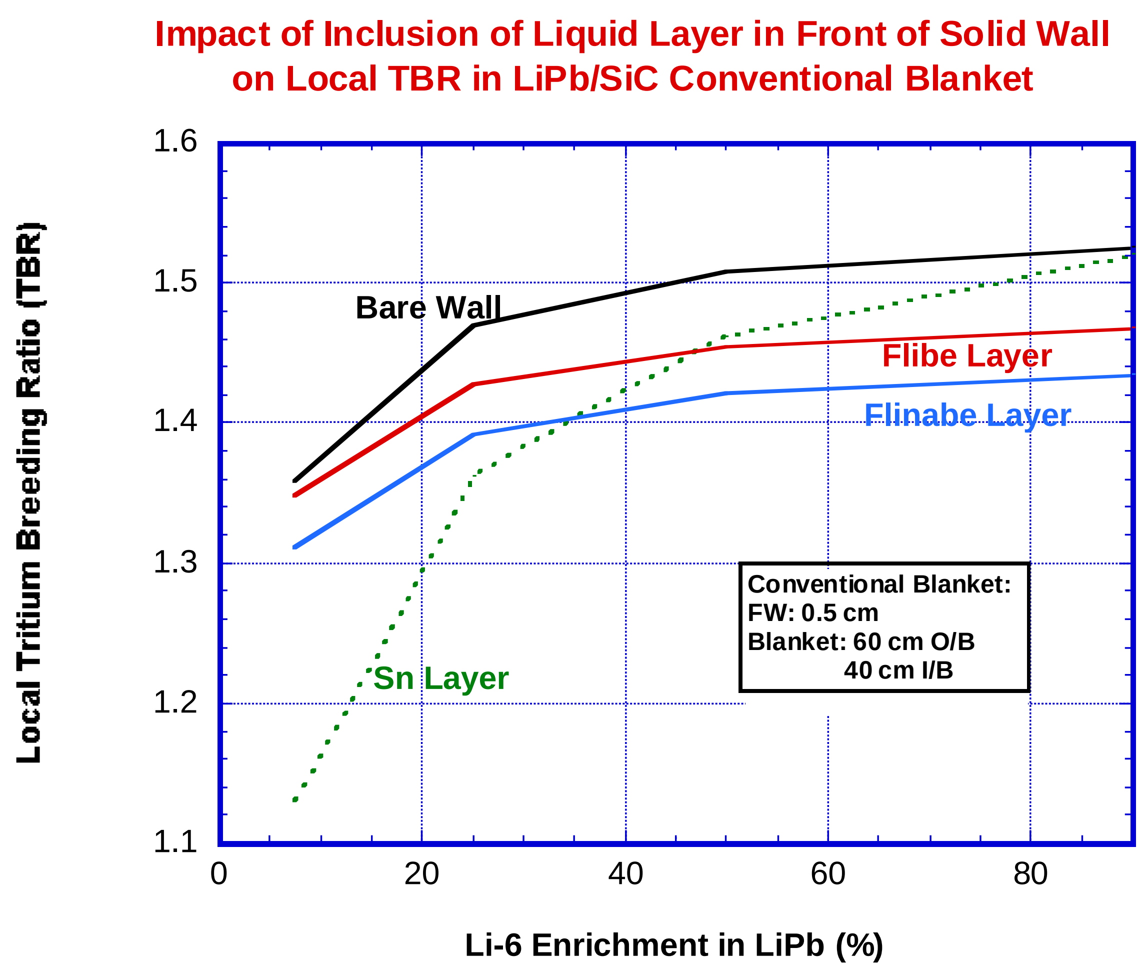
- TBR in Flinabe is less than in Flibe:
  - by ~13% (natural Li)
  - by ~6% (90% Li-6)
- TBR in Flinabe ***is less than unity*** at all Li-6 enrichment
- TBR maximizes at:
  - Flinabe : ~25% Li-6.
  - Flibe: ***natural Li***

TBR Comparison With Beryllium Multiplier



- Significant increase in local TBR is achieved upon inclusion of beryllium zone.
- For the same Be zone thickness TBR in Flinabe is less than in Flibe by:
  - ~4-7% (FS Structure)
  - ~5-9% (SiC structure)
- To achieve the same TBR in Flibe, additional ~3-4 cm of Be zone is needed (for both structure).
- Tritium self-sufficiency can be realized with Flinabe as the flowing layer and breeder.

Effect of Flowing Layer on TBR (LiPb/SiC Blanket)



- If a conventional LiPb/SiC blanket is employed, the local TBR with Flinabe flowing layer is less than Flibe layer by ~3%
- With 2-cm Flinabe layer, tritium self sufficiency can be achieved with LiPb enriched to ~35%Li-6 or higher.
- **Advantage:** no Be zone is needed
- **Disadvantage**: two types of liquid breeder are used

Comments

- *In CLiFF configuration, tritium self sufficiency is not a feasibility issue if Flinabe is used as :*

  1) *A flowing layer and breeder with front Be zone of thickness ~10 cm (60%Be)*

  OR

  2) *A flowing layer only with a conventional LiPb/SiC blanket (35%Li-6 or higher in LiPb)*

- *Other factors might determine the choice between the above two options (e.g. complexity of having two coolants, beryllium resources, materials compatibility, etc.)*

Uncertainties in TBR (required and achievable)

The achievable TBR should be larger than the required TBR with a margin to cover all uncertainties, tritium losses, doubling time, etc.)

Typical values of the uncertainties involved in tokamaks:

Achievable TBR (uncertainties)

- Cross section data: **3-8%**
- Data processing: **4% *(multi-group)*, 2% *(Monte Carlo point data)***
- Homogenization: **2-3%**
- Statistical errors in calculation: **2-3% *(multi-group)* , 1% *(Monte Carlo point data)***
- **1-D Vs. 3-D: ~4% (or ~20%)**

Sub-total uncertaintes : 7-12% (Multi-group), 6-10% (MC)
Sub-total uncertainties (worst) when we use 1-D local TBR: **22%**

Required TBR (uncertainties)

Doubling time (5 yrs): **1%**

- **Burn-up fraction of 5%:** 4%
- Days of tritium reserves (2 d): **~1%**
- Extraction inefficiency in plasma exhaust processing of 0.001: **~2%**
- Residence time in plasma exhaust processing (1d): ~1%
- Blanket residence time (10 d): **~1%**
- Other parameters of fuel cycle: **~1.2%**

Sub-total uncertainties: ~5%

Total uncertainties in TBR:
9-13% (Multi-group),
8-11% (Monte Calro)
Total uncertainties in TBR (worst) when we use 1-D local TBR: **23%**

Typical values for the required TBR in conventional blankets (not thick liquid wall blankets) range *from 1.09-1.12** Therefore, when using the maximum value (1.12), we have:

TBR should be at least 1.35 *(when using 1-D local TBR)*
TBR should be at least 1.25 *(when using MG) with series of 1-D calculations*
TBR should be at least 1.23 *(when using MC)*

******References:***

1- Abdou, M.A., Vold, E.L., Gung C.Y., Youssef, M.Z., and Shin, K., "Deuterium-Tritium Self-Sufficiency in Fusion Reactors", Fusion Technology, 9, (1986) 250

2- Youssef, M.Z. and Abdou, M.A., "Uncertainties in the Prediction of Tritium Breeding in Candidate Blanket Designs Due to present Uncertainties in Nuclear Data Base", Fusion Technology, 9, (1986) 286

3- *Kuan, W. and Abdou, M.A., "A New Approach for Assessing the Required Tritium Breeding Ratio and Startup Inventory in Future Fusion Reactors", Fusion Technology, 35, (1999) 309*