PF Coil Flexibility - Status Report

Review:

- A strawman coilset with 4 PF coils was used in layout drawings for the PVR.

- Subsequent flexibility calculations have shown that the 4 PF coilset is insufficiently flexible, in large part due to the inability of the coilset to provide a good ohmic solution.

- The newly proposed 5 PF coilset (W. Reiersen: 010621_Improved 5 coil PF design.ppt + subsequent tweaking by D. Williamson) produces a much better ohmic solution, and has coil locations better able to produce orthogonal shape field distributions.

We use these coils to determine whether they provide comparable flexibility to that provided by the 4 multipoles used in flexibility studies presented at the PVR.

- For comparison purposes, we use the same modular coilset used for the PVR calculations (i.e., M1017, sized for a 1.7m plasma).

- The PF locations are

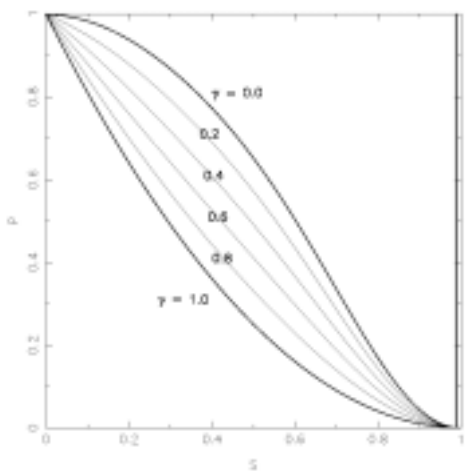
	PF1	PF2	PF3	PF4	PF5
$(R_c, Z_c) =$	(0.305, 0.244)	(0.305, 0.732)	(0.593, 1.312)	(1.618, 1.682)	(3.134, 1.176)

Flexibility Calculations

We test the ability of the modulars + 5 PF coils to produce configurations corresponding to the corners of the flexibility space identified in Ch 9 of the PVR

For example

- the operating space of stable configurations for configurations with different pressure profiles was examined at β = 3.0% (see Table 9.9 of PVR)



- Using multipoles, we found stable configurations with good QA at β = 3.0% for γ = 0.0 => 0.8.
- We test if a stable configuration with good QA can be found using the γ = 0.8 profile.

- Similar tests are done (or TBD) for current profile variations, ι scans and I_p - β scans

Calculation Strategy

- Start with input files corresponding to final (“best”) states obtained by Stellopt-LM for the flexibility calculations presented in the PVR document.

- Modular coil currents are clamped, and the finite multipole fields are set to zero. The 5 PF coil currents are initially zero (we should really do a fit to the multipole fields!) and Stellopt-LM optimizes the physics properties of the configuration by allowing the 5 PF coil currents to vary.

- If the optimum has inadequate physics, the modular coil currents are allowed to vary along with the PF coil currents, and a new optimum is sought.

Results

The following configurations have been studied so far:

(1) I_p – β Scan:

PVR9.4_I0625B10_5PF corresponding to I_p = 43.5kA, β = 1.0% in PVR Table 9.4

PVR9.4_I2500B10_5PF : : : : I_p = 174 kA, β = 1.0% : : : :

(Recall that these were used to illustrate the ability to test β limits at low (day one) β)

PVR9.4_I2500B50_5PF : : : : I_p = 174 kA, β = 5.0%
- a high β, full current case

The first two of these cases have good solutions.

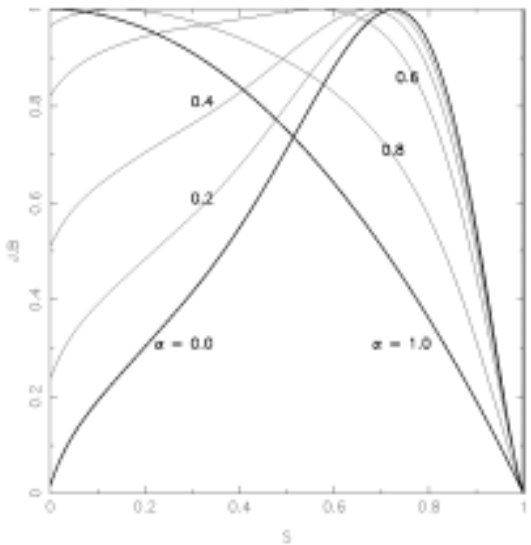
The 1st wall boundary constraint of the third case is not great (-2.42 cm violation), but this is probably an artificial problem and of little concern!

Results (cont)

(2) J.B profile scan:

PVR9.7_A=0.3_5PF corresponding to profile with α = 0.3 in Table 9.7

PVR9.7_A=0.5_5PF : : : : α = 0.5 in Table 9.7

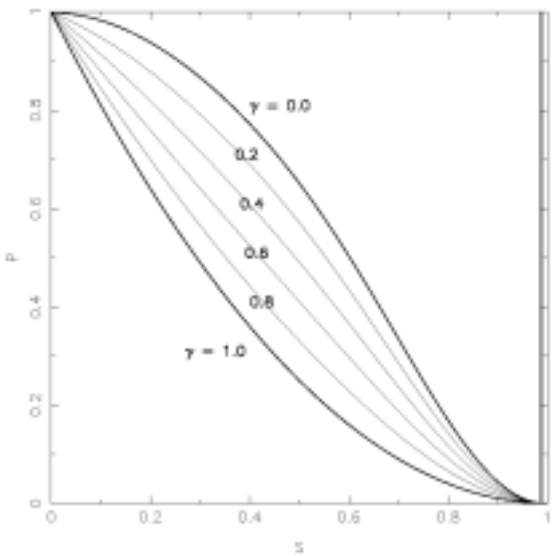


- Using the new 5 coil PF set, configurations were found with physics properties very similar to those presented at the PVR (α = 0.3 definitely inside the stable window of current profiles, α = 0.5 at the boundary for this class of profiles)

Results (cont)

(3) P profile scan:

PVR9.9_G=0.8_5PF corresponding to profile with $\gamma = 0.8$ in Table 9.9



- Physics properties are very similar to those presented at the PVR

Results (cont)

(4) ι profile scans:

- These are in progress but proving to be the most problematic for the adopted computing strategy.

- Main problem is satisfying 1st wall constraint.

- Will try to initialize PF coil currents by fitting procedure to multipoles on stellarator boundary

Calculated PF coil currents for completed scans

Run ID	I_{PF1}[kA-t]	I_{PF2}	I_{PF3}	I_{PF4}	I_{PF5}	Vsec [W]
PVR9.4_I0625B10_5PF	120.	3600.	- 87.	310.	-180.	0.5
PVR9.4_I2500B10_5PF	7.	1300.	- 850.	240.	- 94.	- 0.0
PVR9.4_I2500B50_5PF	210.	1400.	- 540.	0.	0.	0.1
PVR9.7_A=0.3_5PF	- 280.	3400.	-1500.	170.	- 56.	- 0.5
PVR9.7_A=0.5_5PF	- 210.	2900.	-1500.	180.	- 64.	- 0.1
PVR9.9_G=0.8_5PF	390.	750.	250.	180.	- 38.	0.5

76 x 24 kA = 1824 kA.

PF2 is seen to be large in some cases. **(76 x 24 kA = 1824 kA)**
However, Stellopt was not asked to minimize ΣI_j^2, and no flux linkage constraint was imposed.

(These constraints can now be imposed by the latest version of Stellopt (Mike Z.))

Conclusions

The latest 5 coil PF set looks promising but calculations are not yet complete.

In particular, the iota flexibility calculations need to be completed

Estimated date to complete assessment of 5coil PF coilset: Aug 15