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DESIGN, CONSTRUCTION AND OPERATION OF A SMALL RFP FOR TURBULENT PLASMA STUDIES

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14. Abstract/Notes

A small RFP (Reversed Field Pinch) apparatus for turbulent plasma studies, which is called CECI (Configuração de Estrição a Campo Inverso), is described. The apparatus has a major radius of 12cm and a minor radius of 4.2cm. First plasma experiments are scheduled to start in October 1987.

15. Remarks

To be presented in the "Energy Independence Conference: Fusion Energy and Plasma Physics", August 17-21, 1987, Rio de Janeiro, Brazil.

turbulence which accelerates the relaxation process to the minimum energy state. In addition to the above mechanisms, nonlinearly driven reconnection model[3] was also recently proposed.

For these theoretical models, the experimental evidence is insufficient. Our experiment was proposed to study the mechanisms that are relevant to explain the self-reversal of the toroidal field.

2 - EXPERIMENTAL OBJECTIVES

Recently, as Table I clearly shows, RFP experiments are being actively carried out, because its possibility as an alternative to Tokamak for being a fusion reactor has been boosted by the achievement of high electron temperature[4]. Consequently, most of these experiments are aimed to confirm the confinement scaling (CS) in ever larger experimental devices. On the other hand, the RFP plasma presents some interesting basic problems that are not yet completely solved, as the generation of toroidal field inside the flux conserver described in the preceding section. Moreover, many experiments show that the ion and the electron temperatures are almost the same, which suggests the presence of an anomalous heating for ions, viz., turbulent heating and so on. The small RFP experiment described in this paper was planned to investigate such basic problems, namely the following objectives are pursued:

1) studies on the generation of field reversal;
2) studies on the behavior of the plasma edge;
3) studies on the toroidal divertor and the high current density in short discharge times.

Considering the first problem, the current rise time of the poloidal coil system can be selected by properly changing the coil connections to be either 84μs or 170μs. This allows a separation of the two possible macroscopic instabilities that can lead to a relaxation or reconnection process causing the field reversal, namely, the ideal MHD modes that have a characteristic growth time $\tau_{MHD} \approx 90$ns and the resistive modes

the poloidal current in plasma causing the reversal field is produced only by the dynamo effect in plasma. It is mentioned, here, that a toroidal magnetic divertor configuration may be produced at a break region of copper shell because the direction of external field is always the same, even when the field inside the copper shell reverses.

On the other hand, the multiturn poloidal coil system is wound along the toroidal direction around the copper shell with a quasi superconductor current distribution. Figure 4 shows the field profile on the equatorial plane produced by the poloidal coil. The leakage field inside the poloidal coil is shown in Fig. 5[8]. A merit of this type of coil configuration is that a better matching with the condenser bank can be obtained, especially in a small toroidal machine with a small aspect ratio, than using an ordinary single turn coil of the shell type. By this feature, it may be hoped that a high current density operation may be possible, which is one of our experimental objectives.

The variation in the working gas species (H_2, He, Ar and N_2) will let us study a relation between the relaxation process and the magnetic Reynolds number S[9] ($= \tau_D/\tau_A$, where τ_D and τ_A are a diffusion time and Alfvēn transit time, respectively). Before the discharge, the gas is locally preionized by the J x B gun that takes the advantage of the D.C. toroidal field.

The diagnostics used in this experiment are mainly of the standard types, except for a directional probe, as shown in Table III. The directional probe[10] which is an asymmetric double probe to measure an ion current is employed in RFP experiment for the first time. Through this measurement, the plasma flow in the peripheral region and, if possible, in the inner region of plasma will be measured to study the relation between the relaxation process and the plasma flow.

The experimental device is being constructed and tested[8]. Plasma experiments are planned to start in October 1987.

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TABLE CAPTIONS

Table I Reversed Field Pinch (RFP) Experiments.

Table II Machine Parameter in CECI Apparatus.

Table III Diagnostics in CECI Experiment.

FIGURE CAPTIONS

Fig. 1 The distributions of toroidal field B_ϕ and poloidal field B_θ in RFP, based on the Bessel Function Model.

Fig. 2 F-θ diagram.
The solid curve indicates a locus of minimum energy state based on the Bessel Function Model.

Fig. 3 Schematic drawing of CECI apparatus.

Fig. 4 Field distribution on an equatorial surface produced by the D.C. poloidal coil current.

Fig. 5 Leakage field inside the poloidal coil.

Table II - Machine Parameters in CECI Apparatus

Machine Parameters	
Major radius R:	12cm
Minor radius a:	4.2cm
Copper shell	
Major radius R:	12cm
Minor radius b:	4.5cm
Diffusion time for toroidal field	3.4ms
Poloidal coil (air core transformer of 40 or 80 turn)	
Condenser bank	16.85μF (20kV, 3.4kJ)
Current rise time	84μs for 40 turns
	170μs for 80 turns
Maximum loop voltage	500V for 40 turns
	250V for 80 turns
Toroidal coil (D.C. coil of 72 turns)	
Maximum toroidal field	700G
Working gas	H_2, He, Ar, N_2

Table III - Diagnostics in CECI Experiment

Diagnostics	
Magnetic probe:	Distributions of toroidal field $B_\phi(r)$ and poloidal field $B_\theta(r)$.
Rogowski coil:	Plasma and coil currents.
One turn loop:	Loop voltage.
Fourier coils:	MHD activity for poloidal mode number $m \leq 4$ and toroidal mode number $n \leq 12$.
Directional probe:	Direction of a plasma flow.
Faraday cup:	Plasma flux.
Spectrometer:	Behavior of impurity, and ion and electron temperatures.

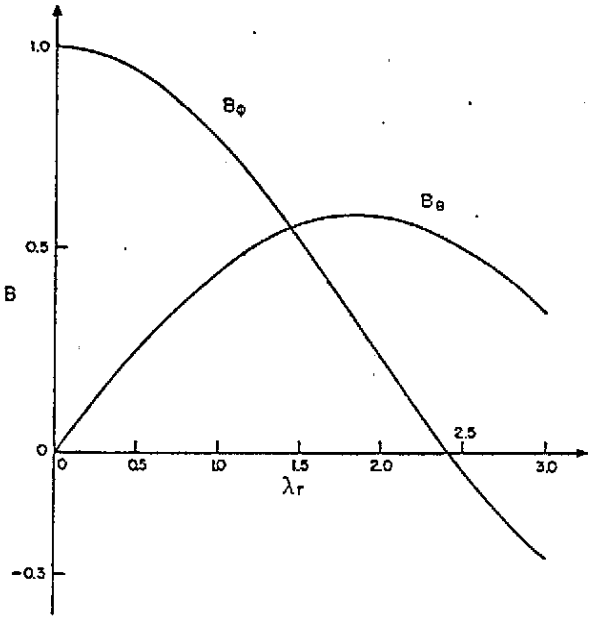

Fig. 1 - The distributions of toroidal field B_ϕ and poloidal field B_θ in RFP, based on the Bessel Function Model.

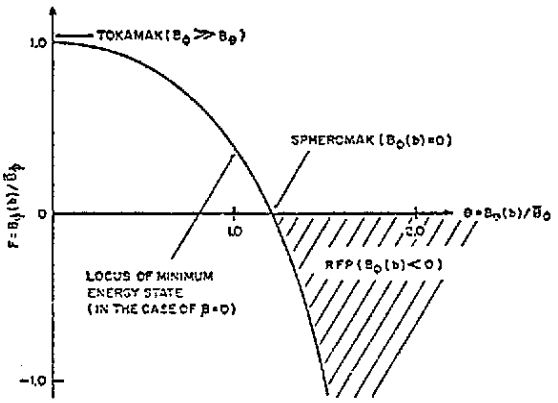

Fig. 2 - F-θ diagram. The solid curve indicates a locus of minimum energy state based on the Bessel Function Model.

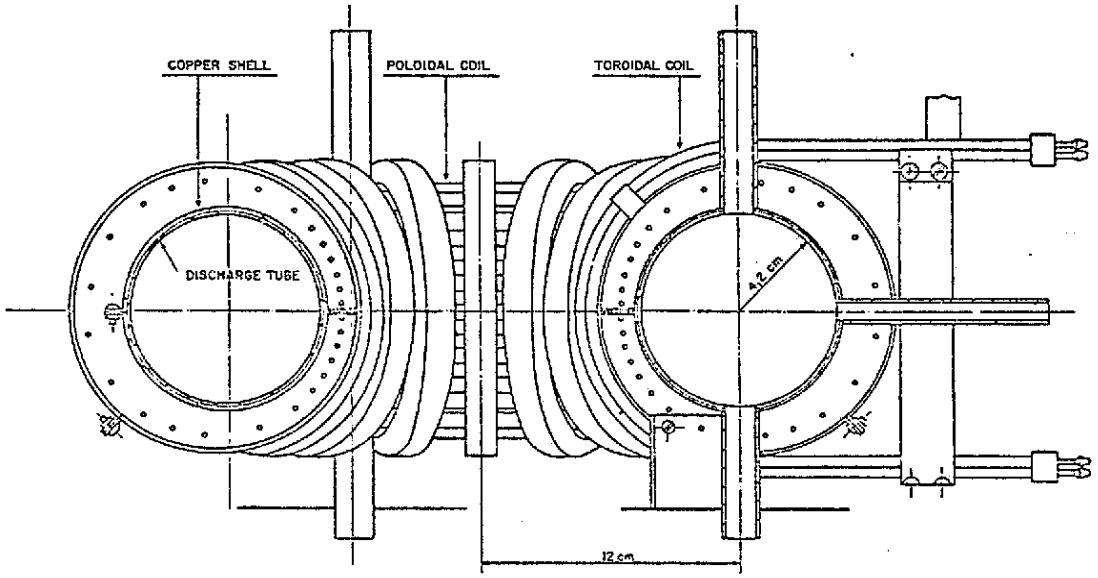

Fig. 3 - Schematic drawing of CECI apparatus.

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[illegible] REVERSED FIELD PINCH, RFP, CECI, TURBULENT PLASMA, DYNAMO EFFECT, SELF-REVERSAL

APÓS A PUBLICAÇÃO, ESTA FICHA SERÁ ARQUIVADA JUNTAMENTE COM A VERSÃO ORIGINAL

INPE 106