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CONFIGURATION DEVELOPMENT AND STRUCTURAL ASSESSMENT OF THE FEDC IGNITOR CONCEPT*

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The FEDC has developed a compact ignition device based on the design approach established by Professor Bruno Coppi of Massachusetts Institute of Technology in his Ignitor concept. Ignitor uses preload of the inner TF coil leg along with bucking of the TF coil against the OH solenoid to minimize the size of the ignition device.

Emphasis has been placed on the configuration design of the reactor core module and the external, hydraulic preload system. Figure 1 shows an elevation view of the FEDC Ignitor concept highlighting the reactor core and the external preload system. The reactor core was designed to allow the fit-up of the toroidal field (TF) coils to meet the requirements of TF wedging, bucking (or the combination of both). The TF coil outboard leg was sized to carry its own in-plane loads; the inboard TF leg was sized to carry the residual tension load (after subtracting preload) plus the wedging/bucking loads. Preload is applied directly to the inboard leg at the top of the device, through an insulation compression block. The outboard half of the TF coil is enclosed in a steel case to support out-of-plane loads. In-plane gaps between the coil and case allow in-plane expansion due to thermal and mechanical loads.

To ease the fit-up requirements of an OH/TF bucking and wedging system plus enhance the torsional strength of the structure, the entire reactor was designed as a welded quadrant. A core quadrant consists of three structural

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subassemblies which house the TF coils and form the TF coil intercoil structure. Final machining of the quadrants are made at the TF-OH interface and at the TF-TF inboard leg interface between quadrants prior to assembling the entire reactor core. Twelve large outboard access ports are not welded to the vacuum vessel until after the entire core module is assembled and the four vacuum vessel interfaces are welded together.

A structural evaluation of all the major components of the FEDC Ignitor was performed during the design configuration development. These components include the reactor core assembly, the toroidal field coil torque structure, and the preload structure.

As part of the compact ignition studies program, a material properties task force evaluated the copper materials considered for the coils in all the concepts developed under the program. The main purpose of the task force was to develop a structural design criteria specifically for the compact ignited device using only the specified copper alloys. The task force then issued a set of guidelines which were used as the structural design criteria for the magnets. Briefly, the criteria applicable to the FEDC Ignitor magnets is to compare the static applied Tresca stress to 85 percent of the tensile yield strength or 70 percent of the tensile ultimate strength, whichever is lower.

The structural design criteria applicable to the external structure basically adheres to the American Society of Mechanical Engineers' Boiler and Pressure Vessel Code, i.e., the static-load Tresca stresses must be less than one-third of the ultimate strength or two-thirds of the yield strength, whichever is less.

The reactor core assembly was analyzed by finite element methods using NASTRAN for the in-plane loads. Out-of-plane loads were evaluated by strength of material methods and combined with the in-plane results. The core assembly includes the toroidal field coils, ohmic heating coil, upper poloidal field coil, steel center post, outer steel reaction rings, and the insulating preload block. The model consisted of one-half of a typical TF coil plate plus corresponding radial segments of the remaining components. Appropriate boundary constraints were applied to each component in the model, while multi-point constraints were used to achieve interaction between the components. Solid, isoparametric elements were used for all components.

Loads evaluated in the NASTRAN analysis include an externally applied preload to reduce the tension in the throat of the TF magnet and in-plane Lorentz forces and temperature loads in both the TF and the OH magnets. Classical strength of material methods were used to evaluate the preload structure and the TF torque structure.

The structural evaluation concludes that all components meet the requirements of the specified structural design criteria.