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RECENT ADVANCES IN DESIGN AND R&D FOR THE QUASI-POLOIDAL STELLARATOR EXPERIMENT*

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The Quasi-Poloidal Stellarator (QPS), currently in the R&D and prototype construction phase, is a very-low-aspect-ratio (R/a ? 2.3, 1/2-1/4 that of existing stellarators), compact stellarator experiment with a non-axisymmetric, near-poloidally-symmetric magnetic field that is more like a linked-mirror configuration than the axisymmetry of other toroidal experiments. The QPS design parameters are <R> = 0.9 m, <a> = 0.3-0.4 m, B = 1 T, a 1.5-s pulse length, and 3-5 MW of ECH and ICRF heating power. The stellarator core consists of a set of modular coils that provide the primary magnetic field configuration, auxiliary coils including vertical field and toroidal field coils, machine structure, and an external vacuum vessel. The modular coils represent the most difficult part of the core design and fabrication and require the most innovation. The coil set has two field periods with 10 modular coils per period and is placed inside an external cylindrical, domed vacuum vessel. The coils are made of internally cooled, flexible copper cable conductor wound on a cast, precision-machined stainless-steel structural winding form and vacuum impregnated with a high-temperature cyanate ester resin. A 3.5-tonne prototype modular coil winding form was cast using a patternless process (machining the sand mold) that resulted in a superior casting with far fewer major weld repairs than a conventional sand casting. The coil form also provides the support features that allow the coils to be connected into an integral structure. The internal cooling tube of the cable conductor is filled with a low-melting-temperature eutectic, which avoids crushing the cooling tube during cable manufacture and winding. The external vacuum vessel avoids the need to fabricate a complex-shaped vacuum vessel in sections, slipping complex-shaped nonplanar coils over the vessel with toroidally varying cross section, and welding a large number of vessel port extensions. However, the modular coil set is in the same vacuum region as the plasma, so the coils must be canned for compatibility with the vacuum. An R&D program is underway that includes extensive conductor characterization and testing, vacuum canning studies, and practice coil winding studies as well as the fabrication of the full-size prototype modular coil. This paper describes the status of QPS engineering design, R&D, prototype construction, and analysis.

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