Impact of Advanced Technologies on Fusion Power Plant Characteristics— The ARIES-AT Study

Farrokh Najmabadi, Mark S. Tillack, A. Rene Raffray, Stephen C. Jardin
Ronald L. Miller, Lester M. Waganer, and the ARIES Team*:

University of California, San Diego, La Jolla, CA

ARIES-AT investigates the potential of high-performance tokamak plasmas together with advanced technology for a fusion power plant. ARIES-AT operates with reversed-shear plasma similar to ARIES-RS but with higher β plasma and better bootstrap alignment. In the fusion technology areas, several advanced technologies are examined in detail:

SiC/SiC composites: Since SiC composites were first proposed in ARIES-I, substantial R&D has been performed and new design ideas developed. The ARIES-AT blanket is made of SiC composite cooled with PbLi. An innovative, yet simple design has been developed which leads to a high coolant outlet temperature of ~1,100 C while keeping the SiC structure below 1000 C. This blanket is well matched to an advanced Brayton power cycle, leading to a gross thermal efficiency of ~60%. The very low afterheat in SiC composites results in exceptional safety and waste disposal characteristics.

Advanced manufacturing techniques aim at producing near-finished products directly from raw material, resulting in low-cost, accurate, and reliable components.

High-temperature superconductors: Both high-temperature (HTSC) and cryogenic superconductors are evaluated for ARIES-AT. Because of high plasma beta in ARIES-AT, the high field capability of HTSC is not utilized. Other advantages of HTSC includes simplification of the cryogenic plant, allowing for more optimized shielding configurations, implementation of low-cost fabrication technique due to the simple internal design.

The 1000-MWe ARIES-AT design has a major radius of 5.4 m, minor radius of 1.3 m, a toroidal beta of 9.2% and an on-axis field of 5.6 T. Plasma current is 13 MA and the current drive power is 33 MW. The ARIES-AT study shows that the combination of advanced tokamak modes and advanced technology leads to attractive fusion power plant with excellent safety and environmental characteristics and with a cost of electricity which is competitive with those projected for other sources of energy.

---

*Work is supported by US DOE. Institution involved in ARIES-AT study, in addition to UC San Diego, are 1) Argonne National Laboratory, 2) Boeing High Energy Systems, 3) General Atomics, 4) Idaho National Engineering and Environmental Laboratory, 5) Massachusetts Institute of Technology, 6) Princeton Plasma Physics Laboratory, 7) Rensselaer Polytechnic Institute, 8) University of Wisconsin - Madison, and 9) Forschungszentrum Karlsruhe