

Session PQ2 on Magnet Opportunities, Goals & Strategy-Aug 6, 1999....rev 0

Goal & Strategy-There are 3 ways for magnet technology to lower the cost of fusion experiments and reactors: 1) reduce the cost of the conductor, magnet components, and/or assembly processes; 2) optimize the magnet systems, so the cost of other subsystems are reduced; and 3) improve conductor and magnet performance to increase the physics performance, e.g. increase magnetic field. The general goal for MFE magnet research in the next 10 years is to reduce the size & cost of magnets by a factor of ~2. For IFE magnets the goal is also a factor of ~2 for KrF magnets and ~2 for HIF system costs. The specific targets are to increase the allowable current density, the working stress and the electric field.

The greatest improvements can be made in the superconducting strand and cable, where a cost reduction factor of 3-10 is possible. This will involve Concept Exploration for innovative conductors, quench detectors, and protection mechanisms not previously used in large scale fusion magnets. It will require an innovative Concept Exploration facility (<M\$1). Consideration should also be given to using superconductors for near term fusion magnets to demonstrate the performance improvements on a larger scale & develop manufacturing technology. For specific cases, the superconducting coils may also be more cost effective for the lifetime of the device.

Design and manufacturing technique improvements for magnet structure should be as significant as improvements in material properties for cost reduction of structure.

Introduction of High Temperature Superconductors (HTS)-Only the Low Temperature Superconductors, NbTi or Nb3Sn, are in use or planned for fusion devices, with the exception of the Levitation Coil for LDX, which will use HTS, BSSCO-2223 tape. In the near and midterm, other HTS magnets must be introduced to prepare for use in Performance Extension experiments. More advanced materials, such as YBCO, depend on development of large quantity fabrication of long conductor lengths. Magnetic fields of up to 20 Tesla and higher operating temperatures than LTS, are possible.

World Program-Significant developments in magnet technology for fusion have been achieved in world programs, but no large fusion programs exist in the U.S to drive magnet R&D. Due to the high cost of the test samples and testing, an efficient way to conduct R&D is through international collaborations, eg-CS Model Coil (JA), TOSKA (EU), SULTAN (EU, & PTF (US).

IFE Magnets-In HIF, because of the large number of small quads in multiple-quad arrays, the stored energy and size is such that a prototype activity is a cost effective approach. The winding distribution, stresses and strains are not the same for an array as for a single quad, so the effort should include an iterative approach with single quads followed by arrays.

The low field requirements and simple geometry of coils for KrF lasers indicates that they are natural choices for near term application & demonstration of performance for HTS superconductors.

Resistive Magnets-Resistive magnet R&D can improve performance and reduce magnet cost for selected missions, either pulsed or steady state. Key issues are: 1) intensive active cooling optimization within mechanical stress limits, 2) simplification of coil & conductor designs, 3) improvement of the radiation compatibility of insulators & conductor materials, & 4) development of demountable TF coils which may significantly improve the tokamak or ST as reactor candidates.

Generic Development-Generic items that would extend machine lifetime and/or reduce costs are: 1) develop insulators with improved radiation resistance, mechanical, electrical properties and processing; 2) use advanced manufacturing techniques (eg- laser forming) and simplified designs; and 3) improve integrated CAD, CAE & CAM. Major benefits could also accrue from advanced code development for conductor & structural analyses.