Plan for Engineering Study of ARIES-CS

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Background

• **Assessment of Compact Stellarator option as a power plant to help:**
  
  - Advance physics and technology of compact stellarator concept and address concept attractiveness issues in the context of power plant studies
  
  - Identify optimum compact stellerator configuration for power plant
    
    - NCSX and QSX plasma/coil configurations as starting point
    
    - But optimum plasma/coil configuration for a power plant may be different
ARIES-CS Program is a Three-Year Study

**FY03: Development of Plasma/coil Configuration Optimization Tool**

1. Develop physics requirements and modules (power balance, stability, $\alpha$ confinement, divertor, etc.)
2. Develop engineering requirements and constraints.
3. Explore attractive coil topologies.

**FY04: Exploration of Configuration Design Space**

1. Physics: $\beta$, aspect ratio, number of periods, rotational transform, sheer, etc.
2. Engineering: configurationally optimization, management of space between plasma and coils.
3. Choose one configuration for detailed design.

**FY05: Detailed system design and optimization**
Year 1: Develop Engineering Requirements and Constraints

Design Process: Optimize design configuration and machine parameters to minimize COE while accommodating design requirements.

**Design Configuration (Engineering)**
- Component Configurations:
  - Blanket
  - Shield
  - Vacuum Vessel
  - Divertor
  - Coils
- Maintenance Scheme

**Machine Parameters (Physics, Coil System)**
- Space between coils
- Minimum plasma edge to coil distance
- Size (major radius)
- Fusion power

**Design Requirements and Performance Parameters**
- Tritium breeding
- Shielding requirements
  - Magnet configuration and heating limits
  - Reweldability
- Thermal efficiency
- Maintenance requirements
  - Size and weight of blanket unit
  - Access
- Safety requirements
Proposed Plan for Engineering Activities

Maintenance Scheme 1
- Blkt/shld/div. 1
- Blkt/shld/div. 2
- Blkt/shld/div. 3

Maintenance Scheme 2
- Blkt/shld/div. 1
- Blkt/shld/div. 2
- Blkt/shld/div. 3

Maintenance Scheme 3
- Blkt/shld/div. 1
- Blkt/shld/div. 2
- Blkt/shld/div. 3

Detailed Design Study and Final Optimization

Machine Parameters and Coil Configurations

Evolve in conjunction with scoping study of maintenance scheme and blkt/shld/div. configurations

Optimization in conjunction with maintenance scheme design optimization

Overall Assessment and Selection

Year 1
- Optimize configuration and maintenance scheme

Year 2
- Optimize configuration and maintenance scheme
- Optimize configuration and maintenance scheme

Year 3

Detailed Design Study and Final Optimization
Engineering Activities: Year 1

- Perform Scoping Assessment of Different Maintenance Schemes and Design Configurations

  Three Possible Maintenance Schemes: (UCSD, PPPL, S. Malang, L. Waganer)

  1. Sector replacement including disassembly of modular coil system (e.g. SPPS, ASRA-6C)

  2. Replacement of blanket modules through maintenance ports arranged between all modular coils (e.g. HSR)

  3. Replacement of blanket modules through small number of designated maintenance ports (using articulated boom)

- Each maintenance scheme imposes specific requirements on machine and coil geometry
Engineering Activities: Year 1

- Scoping analysis of possible blanket/shield/divertor configurations compatible with maintenance scheme and machine geometry, including the following three main classes:

  1. Self-cooled liquid metal blanket (LiPb) (might need He-cooled divertor depending on heat flux)
     a) with SiC$_r$/SiC
     b) with insulated ferritic steel and He-cooled structure

  2. He-cooled liquid breeder blanket (or solid breeder) with ferritic steel and He-cooled divertor

  3. Flibe-cooled ferritic steel blanket
     (might need He-cooled divertor depending on heat flux)

- Evolve coil configuration(s) (PPPL, MIT)
  - Material and thicknesses

  - Radius of curvature, shape

  - Space and shielding requirements
Proposed Analysis Procedure

• Start with coil and plasma shape from NCSX
  - Need alternate concepts from physics (coils) to study better extrapolation to power plant

• Perform scoping maintenance scheme/configuration analysis by scaling (?):
  - Size of machine
    - Distance from plasma to coil
    - Distance between coils
  - Wall load (peak, average, at minimum distance between coil and plasma)

• Need divertor guidelines (heat load, geometry)
Engineering Activities

Year 2: Configuration Optimization Including Plasma/Coil Space Management

- Assess and select best maintenance scheme/configuration pairings
- Optimize each selection including integration of machine/coil parameters and geometry
- Select most attractive integrated pairing(s) for detailed design study

Year 3: Perform Detailed Design Study and Optimization for ARIES-CS Power plant