Contribution ID: **36** Type: **25 min Oral**

Challenges for Engineering Plasma Facing Components for Fusion in Steady-State

Wednesday, 16 November 2022 13:00 (25 minutes)

The first wall and divertor of a fusion power plant (FPP) will experience heat, particle, and neutron fluences well beyond what has been seen for any existing plasma confinement experiments, and beyond what will be seen in ITER. Each plasma facing component (PFC) must satisfy numerous, often competing, requirements. Among the many challenges that must be addressed in designing these components are, neutron activation, particle sputtering and redeposition, erosion, helium implantation, swelling, fuel implantation, stresses produced by thermal gradients and coolant fluid pressure, fatigue from thermal cycling, creep from high temperature operation, etc. Most of these challenges will be present for regardless of which confinement concept is employed for the realization of fusion power. The need for a power plant to operate in long-pulse or steady-state with a high duty cycle will put requirements on these components that cannot be satisfied with current design solutions.

From an engineering standpoint, one issue that must be addressed is the ability to effectively remove heat from the component. The PFC can be conceptually divided into three aspects –the plasma facing (and interacting) surface, the coolant, and the intermediate thermal structure. Currently, many options are being considered for the plasma facing surface, and none are without problems and shortcomings. Tungsten is a commonly assumed candidate, but other materials, including liquid metals, could be explored. Several options are also being considered for the coolant. Water will be the primary coolant in ITER., but water has many limitations when considered for a fusion power plant, not least of which are: the possibility of tritium contamination, the high operating temperature of the wall, and the possibility of transmutation to Nitrogen 16. Helium, liquid metals and molten salt are being considered as alternatives, but further research is necessary before it will be clear that any will be an adequate coolant in a fusion power plant. Finally, the possible compositions and shapes of the intermediate thermal structure are too many to mention. It is clear that PFCs will need to be engineered components, probably several materials in alloy and/or unique shape.

Novel manufacturing, engineering, and simulation methods will be necessary to develop feasible technology for the plasma facing components in an FPP. This is emphasized in the recent US Community Plan: "Recognizing that it is unlikely that existing materials will provide adequate PFC system performance, it is imperative to initiate and sustain a program for the development of new, innovative solid materials that will form the basis of the solid first wall armor, solid divertor targets and the liquid metal PFC substrates through techniques such as advanced manufacturing, nano-engineered materials, material by design, virtual engineering" [1]. This presentation will consider innovations in topology optimization and advanced manufacturing that should enable the development of novel plasma facing components.

[1] Report of the 2019-2020 APS DPP Community Planning Process, A Community Plan for Fusion Energy and Discovery Plasma Sciences, https://drive.google.com/file/d/1w0TKL_Jn0tKUBgUc8RC1s5fIOViH5pRK/view, pg. 53, 2020.

Primary author: LUMSDAINE, Arnold (Oak Ridge National Laboratory)

Presenter: LUMSDAINE, Arnold (Oak Ridge National Laboratory)

Session Classification: RAMI&NT, H&CD session

Track Classification: RAMI (Reliability Availability Maintainability Inspectability) and Nuclear Technologies for Long-Pulse Operation