Additive Manufacturing in the Development of Fusion PFCs

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Additive Manufacturing (AM) has rapidly expanded and AM is now in use in many industries and small businesses around the world. The primary benefits are flexibility in form, as with very light and stiff structures with networks of thin internal walls, and savings in cost through minimization of waste. Other attractive features are the capability (with some processes) to make gradations in material composition and the ease of making subsequent parts in similar layouts with modified dimensions. While the progress includes some impressive development for application to large metallic parts, such as engine blocks, much of the commercial effort involves plastics and materials with relatively low melting temperatures that are not relevant for fusion PFCs. This presentation covers some issues specific to the potential for using AM to manufacture fusion PFCs (plasma facing components) and related concerns about the path forward in R&D for developing such PFCs. For example, two simple initial concerns are thermal management and feature size (surface finish). The speed for 3-D printing per unit volume depends on the thickness of each layer and the relative speed of the printing head across the part. Depending on the process, the part, head, and sometimes both, move.

PFCs relevant for a Component Test Facility (CTF) or a Demonstration Fusion Reactor (DEMO) are likely to be refractory metals. And our choice of materials for fusion PFCs may limit the how effectively AM processes can be utilized. Refractories require high power for melting and the materials of interest for fusion, such as W (tungsten) and Mo (molybdenum), have good thermal conductivity. So the required process must have sufficient input power and dwell time to melt the material; and residual stresses and cracking are likely concerns that depend on how much a printed layer cools before the next layer is added. Rapid deposition of thin layers would in theory minimize cooling of layers and provide fine feature size. If this is a requirement, then the preferred approaches will be “torch-like” processes where the feed material is powder injected at that head, rather than as a layer deposited on the part. Such processes also can apply graded compositions. Other concerns include impurities and micro-porosity.

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