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Prospects for stellarators based on additive manufacturing

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The work studies the potential and limitations of additively manufactured (AM) stellarators deduced from recent experimental works.</p>
High geometric complexity with high accuracy required for stellarator components (so high cost) delays the construction of new stellarators and the related research. Additive manufacturing (AM) is particularly suited to high geometrical complexity at moderate cost. Thus, exploring whether AM might provide advantages to the fabrication and design philosophy of stellarators appears valuable.</p>
Recent experimental works have explored: i) the dimensional accuracy of several coil frame supports and coil casings AM in plastic, ii) a modular coil frame support produced by combination of an AM structure and casting, iii) fibre-resin casting and a liner for a vacuum vessel sector, and iv) an AM full sector of a small stellarator under vacuum and e-beam mapping. The results from such assays are reviewed and integrated in the paper.</p>
Marginally acceptable (0.1% accuracy for 68% of measurements, 1-σ) dimensional accuracy of AM in plastics has been measured. The low stiffness and strength of AM plastics is tackled with the use of fibre-reinforced resin cast in AM hollow truss structures (3Dformwork technique). A copper liner embedded in an AM shell and resin was satisfactorily assayed and, the present high cost of direct metal AM is circumvented by metal electrodeposition on fibre-resin sectors of vacuum vessel (under development). Additionally, in particular for stellarators, the AM inexpensive complexity allows: i) extra design freedom like 3D-printing of features for conductor crossovers or elements for simple and accurate positioning of the stellarator sectors, ii) the use of numerous grooves for the quick winding of numerous and highly contorted coils (so, lower magnetic ripple and wider distance plasma-coils), iii) all stellarator legs produced on a single piece which decrease assembling time. Nevertheless, AM still is burdened with: accuracy limited to 0.1% under the best commercial plastic printers, small size and expensive direct metal commercial AM, low stiffness and strength of plastics or extra complexity of casting or laminating composite resins, long-term dimensional instability of plastics and composites, and size of current commercial plastic printers limited to less than 1-2 m side length.</p>
Additive manufacturing, particularly combined with other traditional fabrication methods, has proved to be at the verge of achieving appropriate performance for small and medium size stellarators. It might accelerate the production of a diversity of stellarator configurations and coil dispositions, of importance for plasma research and for faster evolution of the stellarator research line.

Eligible for student paper award?

No

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