A perspective on the current and future roles of additive manufacturing in process engineering with an emphasis on heat transfer

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Abstract:

Numerous process engineering applications are now exploiting additive manufacturing (AM) to produce more advanced concepts that are delivering demonstrable performance improvements. In the subject area of heat transfer for example, this includes the fabrication of bespoke heat exchangers, recuperators and heat pipes [1,2,3], some of which are specifically being used to solve problems in real industrial settings. In this talk, three specific examples of AM that are being researched in the Process Intensification Group (PIG) at Newcastle University will be discussed, and then abstracted/generalised to provide a perspective on how AM can be best exploited now and in the future. Additionally, this talk will also provide an overview of the current state of AM, and will provide a brief overview of each of the main AM technologies and their major advantages, disadvantages and current/potential applications.

AM might presently be better considered as a tool like any conventional manufacturing process rather than a one-size fits all approach, whereas in the future, AM might become a more integrated tool for the fabrication of plant equipment that hybridises multiple unit operations. The main work prior to the realisation of the latter will be increasing the knowledge-base of PI-technologies – several EU projects are already working toward this goal (examples include IbD and PRINTCR3DIT) [4,5]. The projects in the PIG that will be discussed that are also related to this research goal are: (1) the miniaturisation of the Torbed® technology (Figure 1a) for screening adsorbents for carbon capture (in collaboration with Torftech Group Ltd., Heriot Watt University and University of Sheffield) [6], (2) proposing novel heat pipe wick geometries that could potentially fully optimise the thermal performance of heat pipes (work commissioned by HiETA [7] and SES Engineering Services), and (3) producing bespoke and complex reactor geometries that can be used in conjunction with dynamic reactor operation (e.g. oscillatory flow) to unlock new operating windows (Figures 1b and 1c) [8].

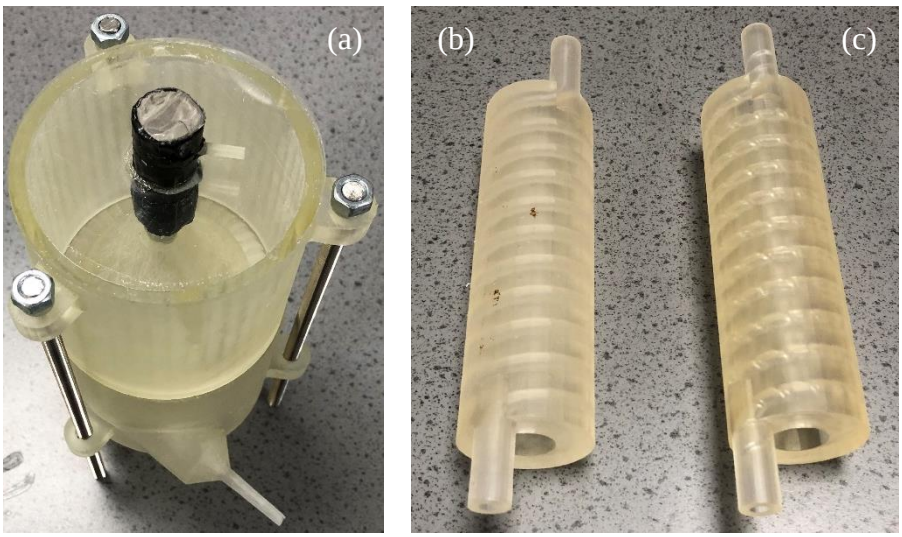

Figure 1. *Examples of research active AM-fabricated reactors in the PIG at Newcastle University: (a) miniaturised toroidal fluidized bed technology, (b) coiled tube reactor, and (c) doubly coiled tube reactor*

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[2] Kiener, C. (2018). Software solutions for digital AM process chains (Siemens). *In:* 1st European Forum on New Technologies: Chemical Engineering & 3D Printing, 7th September, Paris, France

[3] Jafari, D., Wits, W.W., Geurts, B.J. (2018). Metal 3D-printed wick structures for heat pipe application: Capillary performance analysis. Appled Thermal Engineering 143, 403-414

[4] Intensified by Design (IbD), (2019). http://ibd-project.eu/

[5] Grande, C. (2018). PRINTCR3DIT EU Project: Process Intensification through Adaptable Catalytic Reactors made by 3D Printing (Sintef). *In:* 1st European Forum on New Technologies: Chemical Engineering & 3D Printing, 7th September, Paris, France

[6] McDonough, J.R., Law, R., Reay, D.A., Zivkovic, V. (2018). Intensified carbon capture using adsorption: Heat transfer challenges and potential solutions. Thermal Science and Engineering Progress 8, 17-30

[7] HiETA Technologies (2019). https://www.hieta.biz/

[8] McDonough, J.R., Murta, S., Law, R., Harvey, A.P. Oscillatory fluid motion unlocks plug flow operation in helical tube reactors at lower Reynolds numbers (Re ≤ 10). Chemical Engineering Journal 358, 643-657

Bio:

Dr Jonathan McDonough is an early career researcher at Newcastle University who has significant interest and expertise in the areas of reaction engineering, fluid mechanics, flow chemistry, fluidization, heat transfer and 3D printing. Since completing his PhD in January 2018, Jonathan has already been the lead author on 8 publications, with further publications under review/development. One of Jonathan's research themes is to exploit additive manufacturing for the fabrication of new and novel reactor geometries that can unlock previously unobtainable operating windows, paving the way for potentially new chemistries and processes. To this end, Jonathan is actively involved in several complementary projects that explore different aspects of this goal. This means he is now well-equipped to provide a perspective on the potential roles that additive manufacturing will play for the production of new intensified processes now and in the future.