The Computational & Physical Modelling of the Physics of Powder Flow in Additive Manufacturing.

Post Graduate Researcher: Andrew J. Burgess

Contact: A.Burgess@2016.ljmu.ac.uk

School of Engineering, Faculty of Engineering and Technology, Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF, UK

1. Introduction

- Metal Additive Manufacturing (AM), more colloquially known as 3D printing, is a production technique in which parts are generated in a layer-by-layer deposition process, through the interaction of a heat source and powder bed.

- This Ph.D. project uses simulation and modelling techniques, in conjunction with practical experimentation alongside an industrial partner, to analyse the dynamics of powder flow within a vacuum manufacturing chamber.

- Analysis of the current research landscape indicates that powder flowability, whilst crucial to component generation, remains severely underexplored. This project aims to make an original contribution to academia and industry, by identifying the key methods to optimise the powder flow in an Electron Beam Melting AM system, and thereby optimise the overall manufacturing process by generating parts exhibiting stronger mechanical properties in service.

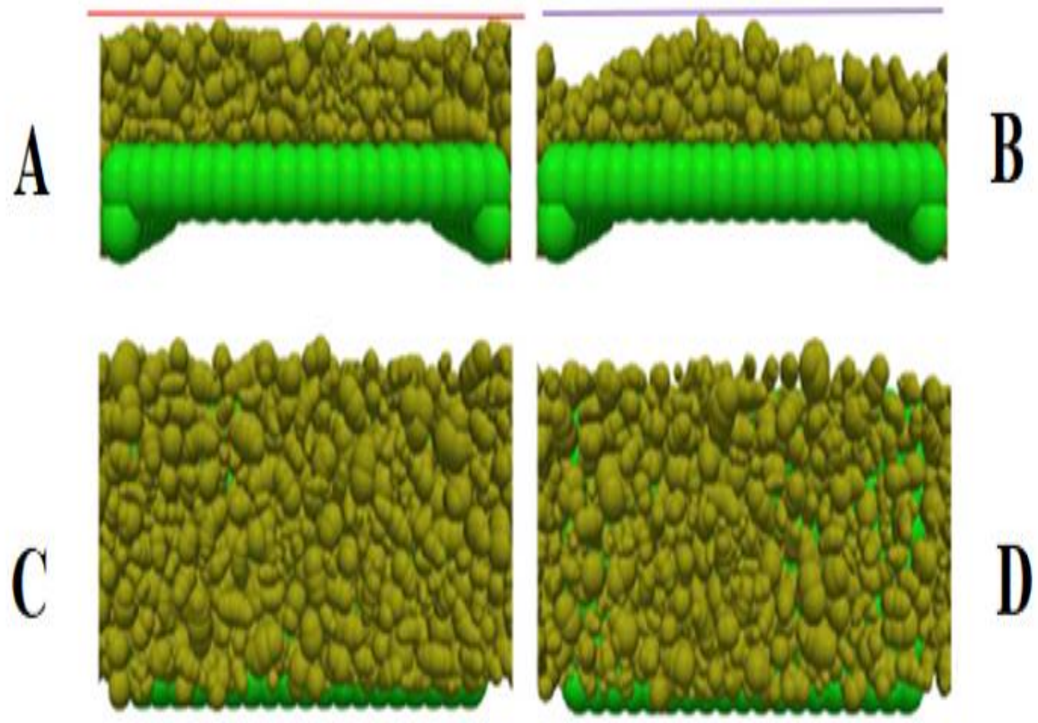

Figure 1: Deposited Powder Layers during the Simulations of Powder Spreading. Adapted from (1).

2. Method

- The project uses the Discrete Element Method (DEM) through an open-source software package, which treats each powder particle as an individual element, to allow for analysis into how the powder bed changes in response to parametric configurations.

- The simulations are informed by the relevant background theories identified during the initial project research, and implement the parametric amendments that are proposed to induce desirable properties to the powder bed and thus, improve the quality of the overall build process and the built components.

- The findings of the simulations are to be validated using practical testing equipment at Wayland Additive Ltd, with whom this project is affiliated. The practical evaluation will involve the design realisation and mechanical testing of the built parts.

3. Current Research Practices

- A critical evaluation of the current research landscape is in progress, to determine the potential areas for exploration that this project may investigate further.

- Previous research has identified 2 key metrics of powder bed quality, how densely packed the bed is, and the surface roughness of the powder layer. **Figure 1** shows a DEM analysis of the powder bed surface roughness, where A and C present the same, smooth layered powder bed at lower recoater velocities, and B and D are the same powder bed at higher values of the recoater translational velocities (1).

- Key processing parameters which influence the quality of the powder bed include particle morphology (shape and size), the size distribution of the powder elements, the speed and shape of the recoating device (which spreads the powder across the substrate to deposit the next build layer), and the type of powder used.

4. Potential Impact

- Conversations with industry (Wayland Additive Ltd, Pfeiffer Vacuum), and scholarly literature, indicate that the optimisation of powder dynamics is an area of great interest for further analysis, with scope for applying the findings of the research project to inform the development of products with greater structural integrity, manifested by a decrease in the microstructural voids observed.

- Improvement of the powder flow, and by extension the manufacturing operation, incurs wider benefits for the production processes, by optimising the powder consumption during the design build and thus reducing the overall operational costs.

- With regards to the academic sphere, successful project conclusions are likely to be well received, with the project work touted to result in a highly ranked Research Excellent Framework publication.

5. Forthcoming Work and Project Aim

- The next area of exploration for the project is to use the DEM to investigate the influence of recoater velocity, and direction, on localised clusters of finer and coarser powder particles within the powder bed.

- The final aim of the PhD project is to establish a set of rules and relationships to enable any metal powder to be analysed for use in an Electron Beam Melting system, and publish the findings online within an online database, whereby its influence on further academic research, and industrial manufacturing practices in commercial environments, can be monitored.

- Reference (1) - Particle-Based Simulation of Powder Application in Additive Manufacturing. Parteli, E.J.R and Pöschel, T. 1, Cologne : Elsevier, 2016, Powder Technology, Vol. 288, pp. 96-102. 0032-5910.