E&I Research Studentship project proposal 2019

Project title: Hybrid additive manufacturing with thermoforming

Supervision Team:
Helen Lockett, School of Engineering & Innovation (helen.lockett@open.ac.uk)
Iestyn Jowers, School of Engineering & Innovation (iestyn.jowers@open.ac.uk)
Richard Moat, School of Engineering & Innovation (richard.moat@open.ac.uk)

Project Highlights:

- Investigate potential applications for a hybrid manufacturing process combining additive manufacturing (AM) with thermoforming
- Perform experimental investigation into hybrid AM/ thermoforming process and propose an initial library of hybrid AM design features
- Investigate a range of different techniques to improve the strength of the bond between additive and thermoformed features
- Develop a demonstrator system and test on industrial case studies

Project Description:

The aim of this project is to investigate a hybrid manufacturing process that will combine Fused Deposition Modelling (FDM) with thermoforming. FDM is an AM technology that uses material extrusion to deposit material into a continuous profile, building up a part layer by layer. Thermoforming is a forming process in which sheet material is heated until it is pliable and then formed into a 3D shape in a mould. Thermoforming is cheaper than injection moulding in low to medium production volumes, but its limited shape complexity can reduce the performance of thermoformed components. It is proposed that using a hybrid approach will give increased design freedom compared to thermoforming, and reduced manufacturing time/ cost compared to injection moulding or AM alone.

In this project, a hybrid AM process will be developed to build FDM features onto thermoformed components. This will be achieved by utilising a 6 degree of freedom robotic arm as the platform for the FDM. The first stage of the research will be to perform some basic experiments to determine the process parameters that are required for FDM deposition onto thermoformed parts. The experiments will then be extended to a wider range of geometric features.

Once the basic parameters of the hybrid process have been established, a further study will be required to investigate how the strength of the bond between the additive and thermoformed regions can be improved. This will also require consideration of the manufacturing variability of the thermoformed components. Finally, a prototype hybrid AM system will be developed to test the developed method on industrial case study parts.

This project tackles a new hybrid manufacturing process that will have potential impact on the future production of a large plastic components.

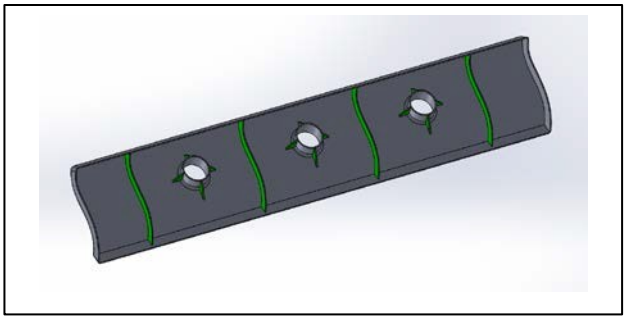

Figure 1: *Example appliction of hybrid AM and thermoforming: Vehicle interior trim panel showing thermoformed component in gray and AM features in green*

Research Methods:

The project will start with a literature review of FDM, thermoforming and hybrid AM technologies. The literature review will focus on the material properties, process parameters and path planning. The project will then follow an experimental approach to investigate the feasibility of hybrid AM/ thermoforming and ways to improve the bond between the thermoformed and AM features. In the final year of the PhD, a demonstrator system will be built to test the developed methods and industrial case studies will be used to assess the results.

Indication of project timeline:

Year 1: Literature review and initial experiments for hybrid AM

Year 2: Investigation into bonding between thermoformed and AM features. Development of feature library and design of prototype system hybrid AM system.

Year 3: Build prototype system and test. Complete thesis write-up.

Applications should be sent to **STEM-EI-Research@open.ac.uk** by 28 February 2019

References

[1] Dröder, K., Heyn, J.K., Gerbers, R., Wonnenberg, B., and Dietrich, F. *Partial Additive Manufacturing: Experiments and Prospects with regard to Large Series Production*. in 5th CIRP Global Web Conference Research and Innovation for Future Production. 2016: Elsevier. 122-127.

[2] Bellehumeur, C., Li, L., Sun, Q., and Gu, P., *Modeling of bond formation between polymer filaments in the fused deposition modelling process.* Journal of Manufacturing Processes, 2003. **6**(2): p. 170-178.

[3] Huang, B. and Singamneni, S.B., *Curved Layer Adaptive Slicing (CLAS) for fused deposition modelling.* Rapid Prototyping Journal, 2015. 21(4): p. 354 – 367

Further details:

Candidates should have a background in mechanical engineering. Relevant skills include robotics, computer aided manufacturing, polymer materials, computer aided design. Candidates should be willing to take a hands-on approach to practical problem solving. Please contact **Dr Helen Lockett (helen.lockett@open.ac.uk)** for further information.

Candidate Applications

- 1000 word cover letter outlining how they are equipped in their educational background and expertise to conduct the research project,
- a CV including contact details of two academic references
- An Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process (Note: This is an Advertised studentship and you do not need to submit a proposal).
- IELTs English Language test scores on application. An average of 6.5 and no less than 6 in anyone of the four components. Applicant should have these results when applying.