THE TIMES
THE SUNDAY TIMES
GOOD UNIVERSITY GUIDE 2018
INSTITUTE OF TECHNOLOGY OF THE YEAR

AIT Research

3D Printed End of Arm Tooling (EOAT) of a Robotic Arm

Daniel Ong U Jing

Supervisors: Dr. Seán Lyons, Dr. Declan Devine

Materials Research Institute

Abstract

This research furthers the practice of designing and manufacturing an EOAT for low weight applications by utilising additive manufacturing ("3D Printing") techniques to decrease energy consumption via tool weight savings and provide EOAT on demand allowing for zero inventory lean manufacturing. Since metal parts are stronger than polymer materials, the three-point flexural test is carried out to determine the differences in terms of strength between the materials. This system is benchmarked with an off-the-shelf EOAT as the control against 3D printed EOATs with infill density of 20 % and 100 % respectively. Lower power consumption was recorded as the robot manipulated the lighter 3D printed EOATs.

Introduction

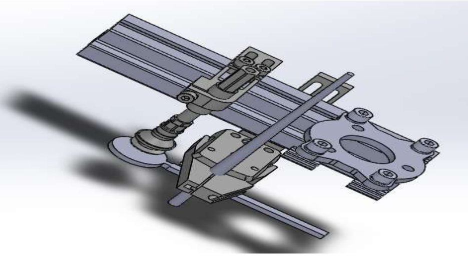
- A robot is a programmable machine capable of carrying out a complex series of actions automatically.
- Robots are able to improve the efficiency of an industrial manufacturing process.
- EOAT is the device attached at the end of a robotic arm to interact with the environment.
- EOATs are able to perform a wide range of functions by using a variety of components assembled for the task.

Aims

- To design and manufacture a lighter EOAT compared to the off-the-shelf part of EOAT.
- To evaluate the inherent advantages and disadvantages of additive manufacturing compared with traditional parts.
- To increase the efficiency of the robotic arm with a lighter EOAT using additive manufacturing.

Why 3D Printing?

- Advantages of 3D printing compared to conventional manufacturing:
  - ✓ Material efficiency
  - ✓ Resource efficiency
  - ✓ Part flexibility
  - ✓ Production flexibility
- Iterate and produce prototypes and production parts rapidly.
- Ability to create parts with lower infill (hollow parts) and complex shapes quickly and easily



References Cited

- America, T. R. I. of. (1981). *NBS/RIA robotics research workshop*. Washington: National Bureau of Standards.
- Boboulos, M. a. (2010). *CAD-CAM & Rapid Prototyping Application Evaluation*. *Bookboon*.
- Glodde, A., & Afrough, M. (2014). Energy efficiency evaluation of an underactuated robot in comparison to traditional robot kinematics. *Procedia CIRP*, *23*(C), 127–130.
- Jiang, C., & Zhao, G.-F. (2014). A Preliminary Study of 3D Printing on Rock Mechanics. *Rock Mechanics and Rock Engineering*, 1041–1050.

Results

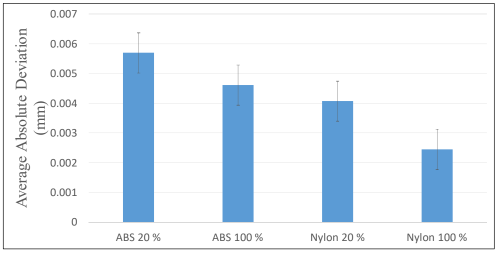


Figure 1: *Average absolute deviations of layer height associated with each group investigated (ABS 20 %, Abs 100 %, Nylon 20%, Nylon 100%).*

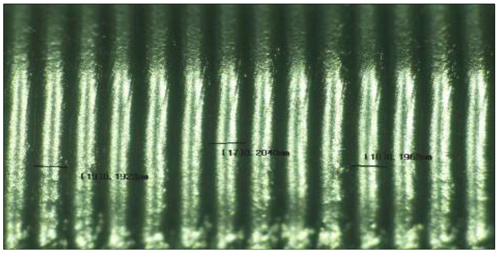


Figure 2: *An image under a digital microscope of a representative ABS with 20 % infill density with layer height measurement.*

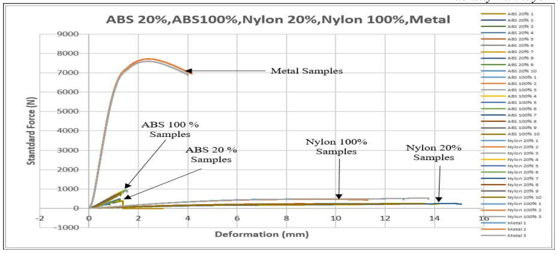


Figure 3: *Flexural behaviour of the samples encountered*

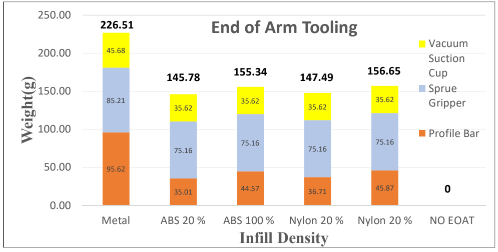


Figure 4: *Weight of the EOAT samples of different material and infill density.*

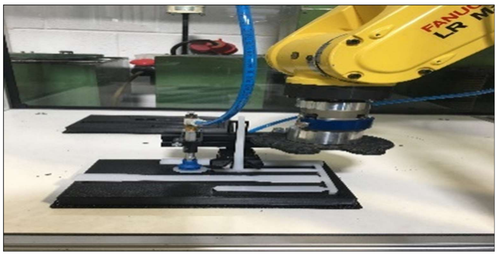


Figure 5: *Robotic arm performing a pick and place task programmed by the user.*

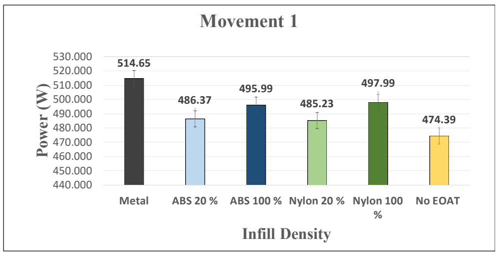


Figure 6: *Peak power measurement of the first trajectory movement.*

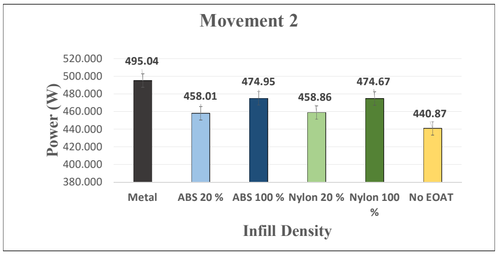


Figure 7: *Peak power measurement of the second trajectory movement.*

Methods

- FDM printer is used to fabricate samples with infill density of 20 % and 100 %
- The material used for the fabrication of the samples were ABS and Nylon (Polyamide).
- The samples density and weight were collected for evaluation.
- Images of the samples were taken to determine the affect of viscosity on the samples layer height using a digital microscope.
- Three-point flexural test is carried out to determine the differences in terms of strength between the off-the-shelf parts and the fabricated sample.
- The robotic arm is then programmed to conduct the task specified by the user.
- The task will be performed with the off-the-shelf parts, followed by the interchange of the printed parts.
- The maximum power of the programmed trajectories is measured.

Acknowledgements

This research was funded by the AIT International President's Seed Fund. Staff in the APT Technology Gateway supported training and equipment needs.

Discussion

- Post hoc comparisons indicated that the Nylon 100 % layer height group has the least average overall deviation at 0.00245 mm (95 % CI, 0.18325 mm – 0.19275 mm), followed by Nylon 20 % layer height group of 0.0407 mm (95 % CI, 0.19152 mm – 0.19643 mm), ABS 100 % layer height group of 0.00461 mm (95 % CI, 0.191277 mm – 0.19667 m) and the ABS 20 % layer height group at 0.00569 mm (95% CI, 0.20115 mm – 0.20606 mm) (Figure 1).
- The variation of layer height of the samples is due to the melt flow behaviour varying viscosity of the polymer materials (Figure 2).
- Thermoplastics could not compete with the strength characteristics of the metal. ABS samples exhibit a brittle behaviour, whereas the Nylon samples exhibit a ductile behaviour (Figure 3).
- The total weight of the off-the-shelf (metal) EOAT is 720.31 g, a 69.86g to 80.72g or roughly 88.79 % to 90.30 % increase over the thermoplastic materials counterparts (Figure 4).
- From Figure 6 and 7, ABS and Nylon 20% samples have the lowest peak power measurement due to having the lightest weight among the other samples.

Conclusion

EOATs can be generated utilising 3D printing quicker than traditional methods. For applications where the EOAT strength is not critical, Additive manufacturing may be utilised to reduce power consumption, contribute to a zero inventory factory and increase Robot Payload capacity.