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Material Choice Driving Sustainability of 3D Printing

Authors : Jeremy Faludi, Zhongyin Hu, Shahd Alrashed, Christopher Braunholz, Suneesh Kaul, Leulekal Kassaye

Abstract : Environmental impacts of six 3D printers using various materials were compared to determine if material choice drove sustainability, or if other factors such as machine type, machine size, or machine utilization dominate. Cradle-to-grave life-cycle assessments were performed, comparing a commercial-scale FDM machine printing in ABS plastic, a desktop FDM machine printing in ABS, a desktop FDM machine printing in PET and PLA plastics, a polyjet machine printing in its proprietary polymer, an SLA machine printing in its polymer, and an inkjet machine hacked to print in salt and dextrose. All scenarios were scored using ReCiPe Endpoint H methodology to combine multiple impact categories, comparing environmental impacts per part made for several scenarios per machine. Results showed that most printers' ecological impacts were dominated by electricity use, not materials, and the changes in electricity use due to different plastics was not significant compared to variation from one machine to another. Variation in machine idle time determined impacts per part most strongly. However, material impacts were quite important for the inkjet printer hacked to print in salt: In its optimal scenario, it had up to 1/38th the impacts coreper part as the worst-performing machine in the same scenario. If salt parts were infused with epoxy to make them more physically robust, then much of this advantage disappeared, and material impacts actually dominated or equaled electricity use. Future studies should also measure DMLS and SLS processes / materials.

Keywords : 3D printing, additive manufacturing, sustainability, life-cycle assessment, design for environment
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