Title: Life cycle cost and environmental assessment of Directed Energy Deposition repair: sensitivity analysis across materials and process parameters

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The repair of metal components using Directed Energy Deposition (DED) technologies offers significant potential to extend component service life, reduce material consumption, and lower overall costs compared to part replacement. However, the economic and environmental performance of DED repair is sensitive to process parameter selection, and this sensitivity can be expected to vary substantially across materials and deposition methods. Despite the growing industrial adoption of DED repair, the quantitative effect of process, material, and parameter choices on Life Cycle Cost (LCC) and environmental impact remains poorly characterized.

This study presents a combined LCC and environmental Life Cycle Assessment (LCA) analysis of DED repair for steel and Stellite alloys, processed via three DED methods: DED-Arc, DED-LB/wire, and DED-LB/powder. A structured sensitivity analysis is conducted for parameters contributing to process productivity, such as deposition rate and layer height. The results indicate that cost and environmental impact metrics mostly scale hand-in-hand with productivity, however the magnitude of change is highly dependent on the material-process combination, as well as the exact tuned parameter.

This analysis provides quantitative guidance on the sensitivity of cost and environmental impact to changes in the DED process across different material and process combinations. The results aid industrial actors in environment- and cost-aware decision making when choosing between DED processes, deposited materials, and process parameters for repair applications.