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12th - 14th September 2025

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Department of Mechanical Engineering

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Advances in Waste Management and Resource Utilization

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Abstract Book

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Anirban Mukherjee

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Sustainable Upcycling of Scrap Metal Sheets via Hydroforming for Circular Manufacturing

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Abstract

The escalating generation of ferrous and non-ferrous sheet metal waste from automotive, construction, and manufacturing sectors necessitates sustainable valorization pathways. This study investigates the application of hydroforming—a high-pressure fluid-assisted forming process—for upcycling heterogeneous scrap metal sheets into high-value, lightweight, and structurally resilient components. The research encompasses material recovery and preprocessing protocols (including de-coating, surface cleaning, and thickness calibration) to mitigate contamination and alloy inconsistency. Experimental trials optimize hydroforming process parameters—fluid pressure profiles, blank holding forces, and strain rates—tailored to recycled sheet properties to ensure mechanical integrity and geometrical precision. Performance metrics include yield strength retention, formability index, springback minimization, and dimensional tolerance compliance. A comparative life cycle assessment (LCA) quantifies embodied energy savings and greenhouse gas (GHG) reduction relative to fabrication from virgin feedstocks. Preliminary findings indicate that integrating scrap metal hydroforming into municipal and industrial waste management streams supports closed-loop material cycles, decreases landfill dependency, and reduces primary resource extraction. The work demonstrates a technically feasible approach that merges advanced forming technology with resource efficiency strategies, enabling scalable implementation within circular manufacturing frameworks.

Keywords: Hydroforming; Scrap metal upcycling; High-pressure forming; LCA; Circular economy; Sustainable manufacturing.