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Bending The Rules: A Review of Cutting-Edge Sheet Metal Forming Technologies

Mohd Aidil Shah bin Abdul Rahim[1,*], Fazlul Rahman bin Mohd Yunus[1], Muhammad Faqrul bin Mohd Zaidi[1] and Saifuldin bin Sabdin[2]

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ABSTRACT

Sheet metal forming (SMF) forms an important part of contemporary manufacturing processes, enabling more complex and lightweight components for aerospace, automotive and infrastructure applications. The overall overview of this paper discusses the evolution of technology in sheet metal fabrication from conventional methods to highly precise digitalized systems. This study systematically classifies a host of applications, including stamping, deep drawing, and hydroforming, incremental sheet forming (ISF) and laser-based deformation, in order to compare their overall mechanical fundamentals including plastic deformation, strain hardening and fracture mechanics that govern structural performance. Analysis revolves around the transition of the field to high strength ultra-light alloy and sophisticated surface treatments as prescribed by the modern sustainable goals. Evidence indicates that the melding of Artificial Intelligence (AI), Digital Twin, and Additive Manufacturing (AM) brings about unprecedented opportunities to maximize manufacturing capacities and minimize systemic waste. The future trends will see a transition towards Hybrid Manufacturing in which the AM-produced rapid tooling and conformal cooling channels embedded into traditional formative processes surpass the existing geometric and thermal limitations. In addition, autonomous closed-loop control and real-time springback compensation driven by multi-physics FEA and machine learning are becoming the industry trends. The circular economy model in terms of bio-lubricants and high-recyclability alloys is recognized as the key to overcoming the current situation and, in turn, forming the basis to a sustainable and resilient global manufacturing structure.