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Intelli-FiX: Additively Manufactured Modular Fixture with RFID and Real-Time Force Sensing for Closed-Loop Automation

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Abstract

This study presents an approach to designing and fabricating a smart modular fixture by integrating additive manufacturing (AM), Radio-Frequency Identification (RFID), a Programmable Logic Controller (PLC), and force sensors. Traditional fixtures are often bulky, costly, and lack adaptability, leading to inefficiencies in manufacturing. To overcome these limitations, we will adapt AM to create a lightweight, customizable, and modular fixture base. The modular design enables rapid reconfiguration for different manufacturing operations and faster setup to accommodate different workpieces, reducing lead times and material waste. In this study we have showcased the capabilities of this system for a drilling operation. The integration of RFID tags on each workpiece enables digitalization of identification and tracking utilizing cloud-based data storage framework. Force sensors are embedded within the fixture to monitor clamping force in real-time, preventing part deformation and ensuring consistent quality. The system provides live feedback, enabling a closed-loop control system for optimized and automated fixture operation. This intelligent fixture design significantly enhances manufacturing flexibility, quality control, and automation, offering a cost-effective and scalable solution for modern production environments.

Keywords
Smart Modular Fixture, Additive Manufacturing, Radio-Frequency Identification (RFID), Programmable Logic Controller (PLC), Force Sensors, Digital Manufacturing

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