AI for Smarter Remanufacturing: Predicting Core Value and Prioritizing Impact

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Remanufacturing is a key pillar of product-life extension within the Circular Economy. Unlike new manufacturing, remanufacturing transforms used products – "cores" – into as-good-as-when-new condition. The process is hindered by the unknown internal condition and varied wear-and-tear of cores, which are the key input materials. This leads to operational inefficiencies such as costly teardowns, wasted labor, uncertain production planning, and excessive overstocking of cores and parts.

We present an AI-driven system that addresses these challenges by transforming remanufacturing from a reactive, physical-first process into a proactive, data-first operation. The system is based on *a priori* evaluation framework that leverages artificial intelligence to predict a core's remanufacturing viability before physical disassembly. Analyzing all available data about a core, such as its operational history, sensor/IoT data, and results of any inspection and physical tests, AI models assess the core's internal condition and predict potential faults. Such AI models could include data-driven models, physical models or hybrid models depending upon the equipment type and available data. Based on this diagnosis and standard operating procedures (SOP), specific parts and processes required for remediation are estimated. If the SOPs are not available, the system leverages Generative AI to synthesize them from manuals and historical remanufacturing logs. This provides an estimated prescription for the repair. For the estimated parts and processes needed for the repair, key economic and environmental metrics, such as costs, labor needs, embedded energy, and emissions are derived. All these factors are synthesized into a single, quantitative "utility measure," which represents the core's potential value or impact if remanufactured. This objective measure is used to automatically prioritize an inventory of cores to confidently allocate remanufacturing resources to the most economically and environmentally valuable cores.

By replacing guesswork with AI- and data-driven insights, our system provides a tool for optimizing production, reducing inventory, and reducing risk. It thus helps accelerate the transition to a more efficient and sustainable remanufacturing operation.