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Advancements in Welding Techniques for Copper Pipes in Heat Pump Systems: A Comparative Analysis

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Heat pumps have emerged as pivotal equipment in the pursuit of decarbonization, offering significantly higher energy efficiency compared to traditional boilers. With the capacity to provide both heating and cooling, heat pumps boast an exceptional thermal efficiency, could reaching around 500%. However, optimizing the manufacturing process of the outdoor unit, comprising approximately twenty components, including a complex network of copper pipes with over thirty welded connections, remains imperative for enhancing efficiency and reducing production time.

While brazing via flame, furnace, or induction stands as the conventional method for joining copper pipes, alternative welding techniques such as LASER, electron beam, and ultrasonic welding present promising alternatives. Despite copper's reflective nature posing challenges for certain LASER technologies, particularly ytterbium fiber or Nd:YAG lasers, those emitting green or blue light at wavelengths near 500 nm demonstrate increased effectiveness. Conversely, vacuum welding methods like electron beam welding offer unparalleled advantages, including the elimination of gas or flux requirements to counteract oxidation, along with minimal heat affected zone.

This study investigates the application of various welding processes to copper pipes utilized in heat pump systems, presenting comparative results to elucidate the most efficient and practical methodologies for enhancing manufacturing efficiency and performance.