New Recuperator Alloy Commercialized

Affordable AL20-25+Nb Alloy Demonstrates Improved Creep and Oxidation Resistance at High Temperatures

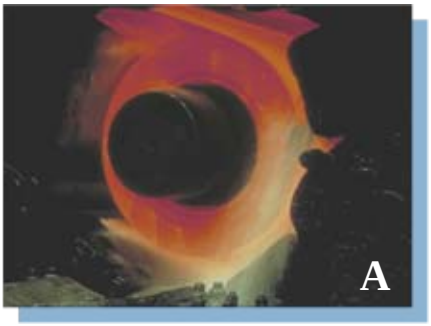
Background

The current DOE Advanced Microturbine Program goal of >40% electrical efficiency will only be achieved as recuperators are enabled to operate reliably at higher temperatures (650-700°C) for extended time periods (>40,000 h). To this end, ORNL has identified a group of commercial alloys for the production of more durable recuperator components. Both lab testing and microturbine experience have shown that standard 347 stainless steel (347SS) is inadequate at 650°C due to moisture-enhanced oxidation and insufficient creep resistance; however, the new Allegheny-Ludlum (AL) alloy, AL20-25+Nb™ (20% Cr, 25% Ni, Nb, and Fe), has outperformed 347SS, demonstrating superior properties in moist, high-temperature combustion environments.

AL20-25+Nb was initially developed in response to the needs of Solar Turbine's new, high-temperature Mercury 50 industrial gas turbine (5 MW) – capable of 38% efficiency. ORNL and AL collaborated to produce and characterize a broad range of AL20-25+Nb commercial sheets and foils for the recuperator needs of microturbine manufacturers. During 2005, the partners modified the alloy processing conditions to optimize the creep resistance of the new alloy.

Technology

During Phase I of this collaborative project, 5000 lb of original hot-band was reduced into over 1000 lb of foils (0.004, 0.005, and 0.008 inch gage thickness) and 800 lb of sheets (0.010 and 0.015 inch gage thickness). ORNL creep–rupture testing and microstructure analysis of the 0.004 and 0.005 inch foils confirmed that AL20-25+Nb alloy strength surpassed that of standard 347SS

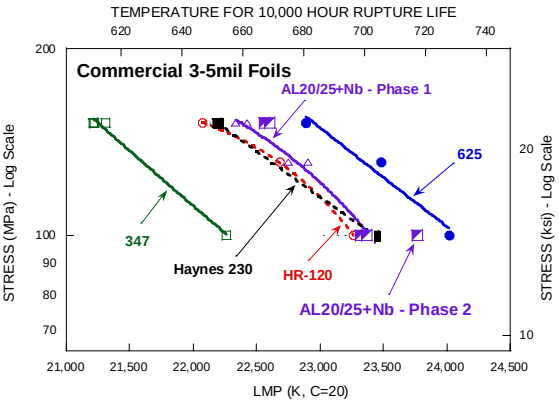


The AL20-25+Nb stainless alloy was melted as a large ingot. It was then formed into foils and sheets through typical commercial rolling of hot-band (A), cold-rolling and annealing (B), and slitting to the exact widths required by each recuperator manufacturer (C).

at 700-750°C and performed as well as foils of HR120, HR230, and other commercially-available, high-performance alloys.

Ingersoll Rand Energy Systems (IRES) received the foils and sheets to fabricate brazed plate-and-fin (BPF) air cells for the recuperators used for the company's new 250 kW microturbines. AL20-25+Nb passed all preliminary IRES tests for BPF air-cell manufacturing and brazed as well or better than 347SS.

In the Phase II effort to further enhance creep-resistance, several hundred pounds of 0.0032 inch AL20-25+Nb foil was produced for Capstone. The foils were used in manufacturing trials for the welded primary surface recuperator (PSR) for their 60 kW and 200 kW microturbines. The Phase II foil strength surpassed that of HR120 and approached that of alloy 625, a Ni-based superalloy. Moreover, AL20-25+Nb is cost-effective upgrade to 347SS when compared to these other more expensive alloys.



Phase II AL20-25+Nb foils demonstrate good creep-resistance when compared to 347SS and other more expensive alloys.

Benefits

- **Improved Strength and Oxidation Resistance** – Foils and sheets of AL20-25+Nb demonstrate better creep and oxidation resistance than those of 347SS at 650-750°C. Rupture ductility of the new alloy is 20-25% (347SS is 3-10%) which further enhances cyclic microturbine operation. In addition, the improved oxidation resistance of the alloy should be more resistant to contaminants present in landfill gas and other alternative fuels.

- **Affordability** – AL20-25+Nb is one of the most cost effective alloys for upgrading recuperator capability, reliability, and performance. The Ni-based superalloy HR230 is strong as a plate, but weak as a foil and 7 times the cost of 347SS. Alloy HR120 and Inconel 625 cost 3.5 times and 5 times the cost of 347SS respectively. AL20-25+Nb is only 1.5 to 2 times the cost of 347SS.

- **Good Manufacturing Properties –** Good welding and brazing behavior should make AL20-25+Nb a promising alternative for many other heat-exchanger technology applications.

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