Creep Testing of High-Temperature Cu-8 Cr-4 Nb Alloy Completed

A Cu-8 at.% Cr-4 at.% Nb (Cu-8 Cr-4 Nb) alloy is under development for high-temperature, high-heat-flux applications, such as actively cooled, hypersonic vehicle heat exchangers and rocket engine combustion chambers. Cu-8 Cr-4 Nb offers a superior combination of strength and conductivity. It has also shown exceptional low-cycle fatigue properties. Following preliminary testing (ref. 1) to determine the best processing route, a more detailed testing program was initiated to determine the creep lives and creep rates of Cu-8 Cr-4 Nb alloy specimens produced by extrusion.

Testing was conducted at the NASA Lewis Research Center with constant-load vacuum creep units. Considering expected operating temperatures and mission lives, we developed a test matrix to accurately determine the creep properties of Cu-8 Cr-4 Nb between 500 and 800 °C. Six bars of Cu-8 Cr-4 Nb were extruded. From these bars, 54 creep samples were machined and tested.

The figure on the left shows the steady-state, or second-stage, creep rates for the samples. Comparison data for NARloy-Z (Cu-3 wt % Ag-0.5 wt % Zr), the alloy currently used in combustion chamber liners, were not available. Therefore the steady-state creep rates for Cu at similar temperatures are presented (ref. 2). As expected, in comparison to pure Cu, the creep rates for Cu-8 Cr-4 Nb are much lower. The lives of the samples are presented in the figure on the right. As shown, Cu-8 Cr-4 Nb at 800 °C is comparable to NARloy-Z at 648 °C. At equivalent temperatures, Cu-8 Cr-4 Nb enjoys a 20 to 50 percent advantage in stress for a given life and 1 to 3 orders of magnitude greater life at a given stress. The improved properties allow for design tradeoffs and improvements in new and existing heat exchangers such as the next generation of combustion chamber liners.
Currently, two companies are interested in the commercial usage of the Cu-8 Cr-4 Nb alloy. The Rocketdyne Division of Rockwell International is conducting independent testing to analyze the properties for their projected needs in advanced rocket engine applications. Metallamics, a company based in Traverse City, Michigan, is entering into a Space Act Agreement to evaluate and test Cu-Cr-Nb alloys as materials for welding electrodes that are used in robotic welding operations. Creep rate is one of the alloy properties that determines the degree to which a welding electrode will mushroom or expand at the tip. A material with a low creep rate will resist mushrooming and give the electrode a longer life, minimizing downtime. This application holds the potential for large-scale usage of the alloy in the automotive and other industries. Success here would dramatically decrease the cost of the alloy and increase availability for aerospace applications.

References
