The Next Generation of High Temperature Alloys

Tim Gabb

This topic concerns the next generation of high temperature alloys, and is sponsored by the TMS High Temperature Alloys Committee. Near-term developments on nickel-base superalloys are presented, as well as longer term considerations for cobalt-base superalloys and titanium aluminide intermetallic alloys.

Successive nickel-base superalloys used for turbine blades over the years have increasingly high densities. In the first paper, R.A. MacKay and co-workers describe development of new low density single crystal superalloys for turbine blade applications. These alloys provide a low-risk balance of mechanical properties comparable with the best current blade superalloys, but with significantly reduced alloy densities.

Superalloys sometimes have high cost, exotic elements, added during development for various reasons. P.J. Fink and his co-workers review the efforts at GE Aviation to revert, recycle, recover, and reduce the element rhenium in airfoil superalloys. Rhenium content was reduced and even eliminated from a current, very widely used blade superalloy Rene N5, while maintaining mechanical properties. Recycling efforts have also been enhanced.

New cobalt-base superalloys are being designed to have $L1_2$ γ' precipitate strengthening. T. Pollock and co-authors cover their work on such new cobalt-base γ-γ' superalloys. These superalloys have solidus and liquidus temperatures that are 100–150°C higher than current nickel-base single crystal blade superalloys and may offer higher resistance to convective instabilities causing chemical segregation.

Titanium aluminide intermetallic alloys may potentially be substituted for nickel-base superalloys in some applications, with greatly reduced densities. H. Zhu and co-authors review microstructure-property relationships in TiAl intermetallic alloys. Beta phase can be carefully controlled through heat treatment to precipitate at lamellar interfaces for improved creep resistance.

However, titanium aluminides have non-protective mixed oxide scale formation during high temperature exposures in many oxidizing environments. A. Donchev and co-workers describe a novel fluorine treatment for these alloys, which allows formation of a pure, protective alumina scale. This could enable their use at service temperatures well beyond 800°C for certain future applications.

The mission of the TMS High Temperature Alloys Committee is to provide a means of communication among those interested in superalloys and other high temperature alloys. The High Temperature Alloys Committee Web site provides ample additional information at *org/admin .html?divisions/SMD/SMDmain.asp*. The committee's emphasis is on communicating new technical information and critical reviews on the technology of high temperature alloys. Symposia concerning high temperature alloy topics are usually sponsored by the committee at TMS Annual and Materials Science and Technology (MS&T) meetings.

In addition, an International Symposium on Superalloys is held every 4 years in cooperation with TMS, the High Temperature Alloys Committee of TMS and ASM International. This symposium is organized by the Seven Springs International Symposium Committee. The 11th meeting of this symposium was held September 14–18, 2008 at the Seven Springs Mountain Resort, Champion, Pennsylvania. A total of 460 attendees, including 75 students, participated in six oral sessions having 46 oral presentations and five interactive sessions having 63 poster presentations. Topics covered included alloy and process advancements, microdeformation and macroscopic properties, coatings and environmental effects, high temperature behavior, and associated modeling, simulation, and validation. A shortened "Research Summary" version of the nominated best paper of the symposium, "A Coupled Creep Plasticity Model for Residual Stress Relaxation of a Shot-Peened Nickel Base Superalloy," by D. Buchanan and co-workers, is included after our previously mentioned papers. A bound volume of the symposium's entire proceedings, *Superalloys 2008,* is available from TMS at *http://knowledge .tms.org/superalloys.aspx*.

The High Temperature Alloys Committee is also sponsoring an International Symposium on Superalloy 718 and Derivatives on October 10–13, 2010. Jon Groh presents an introduction to this important upcoming symposium in the accompanying pages. Further information is available at *www.tms.org/Meetings/specialty /superalloys2010/home.aspx*.

The committee usually meets on Tuesday evening at the TMS Annual Meeting in the spring and MS&T meeting each fall. All researchers working on high-temperature alloys are invited to participate.

Tim Gabb is with NASA Glenn Research Center in Cleveland, Ohio and a member of the High Temperature Alloys Committee of the Structural Materials Division of TMS.