Modeling Titanium Alloys and Processes

Mike Peretti

The old saying goes that the only sure thing is change. Looking back only a year it is unlikely that most would have predicted the conditions that we now face. The aerospace business tends to lag some months behind the general economy, mostly because of the long-term nature of deliveries and order backlogs, so titanium's biggest market may stand out more against the unfolding scene.

The titanium metal industry has been no less affected by deteriorating global economic conditions than other sectors. This has been especially evident as the industry has come off of its tremendous pace of 2007 only to slow down late in 2008 and continue this trend into 2009. As always, there is cause for both concern and optimism on the horizon; this industry is never one to stand still for long. Delays in production and delivery of new airframes are becoming more commonplace. As the U.S. Defense Department crafts its budget and future strategy there is uncertainty over the fate of several large aerospace programs. New projects on a global scale, however, can provide opportunities in areas such as infrastructure (water purification and supply, for example) and energy projects (exploration, generation, processing, transmission) in traditional and emerging technologies.

It is against this backdrop that we look for ways to get the most out of engineering and technology programs that improve the bottom line both in the long and short term. One of the most practical approaches to this is the use of modeling methods to explore new alloy systems as well as design and improve processing routes to make manufacturing more economical. New alloys offer expanded markets through improved or specialized properties sets. Optimized processing routes go directly to a company's bottom line as decreased costs and offer flexibility throughout the supply chain. In this issue we will take a look at how modeling can be used in these areas at a practical level.

Mathematical modeling is not a new concept. Virtually all projects begin with simple models that give confidence, on first principles, that an idea is viable or not. Ever-increasing computing power and software development, especially in user interfaces, has made sophisticated modeling available to companies and institutions of all sizes. Many small companies now distinguish themselves from their competition by their ability to design, through modeling and experience, in a more cost-effective manner.

This *JOM* issue's look into the world of modeling examines a wide range of applications in the titanium industry and is an excellent example of the use of different modeling approaches to suit different needs. We will examine cold and hot deformation processes, look at the design of new alloys, and investigate a process to reduce the cost of primary titanium production.

The first article, by V. Venkatesh et al., looks at the application of commercial finite element software to large-scale thermomechanical processing at a major titanium producer. Process optimization at such a scale improves not only costs, but also just as importantly the quality of titanium mill products. Another extremely important benefit to the application of modeling in this fashion is reduction in overall energy consumption, and therefore carbon emissions, in titanium processing; a notoriously energy-intensive metal to produce.

The second paper, by G.Q. Wu and W. Sha, proposes a method for modeling cold deformation in titanium alloys. Its emphasis on the physical metallurgy of cold forming aims to develop a quantitative microstructure model for the relationship between cold deformation and properties, not simply the prediction of the final shape of a deformed part. The work is focused on the cold heading process.

The third paper, by K.T. Jacob and S. Gupta, explores how the chemical potential diagram for oxides can assist in the development of new titanium reduction processes by calciothermic routes. The results can be applied to both direct metallothermic reduction and electrochemically assisted reduction methods.

H. El Kadiri et al. examine the use of simulation techniques in the development of new titanium alloys based on the Ti-Fe-Zr system and using powder metallurgy techniques. The results are used to predict densification behavior during the vacuum sintering process to achieve maximum densification during pressure-less sintering.

The next *JOM* technical emphasis topic for titanium will be cost-affordable titanium processing and will appear in 2010. This is always an exciting area, with new developments occurring at a rapid pace that hold great potential to inject new titanium applications into the marketplace. What new changes will the coming year hold?

Mike Peretti, Senior Staff Engineer with GE Aviation in Newark, DE, is the advisor to *JOM* from the Titanium Committee of the Structural Materials Division of TMS.