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Deformation and Forming of Joined Materials

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As manufacturers strive to improve product performance and reduce weight, particularly in the transportation industries, designers are optimizing material usage with combinations of many different materials and alloys. The goal is to optimize mechanical behavior by selecting material specifically tailored for locations within a product or component. Such mixed material solutions require innovative joining technologies to combine, for example, aluminum and steel or magnesium and carbon fiber composite, etc. Critical to expanding the use of such joined materials in structural applications is the relevant technical understanding of how they form and deform across varying strain rates ranging from superplastic forming to stamping to crash events. With an increasingly rapid development of advanced materials, knowledge gained by assessing the post-weld formability of joined similar and multimaterial structures is crucial to providing the data needed to enable more widespread utilization. On the other end of the spectrum, increased insight characterizing the deformation of these joined structures is also critical to paving the way toward successful implementation. Characterizations via experimentation as well as predictive capabilities are essential to this effort as explored by the articles included in this issue.

First, Judy Schneider and Ron Radzilowski provide a history of various processes for joining aluminum and iron-based materials in "Welding of Very Dissimilar Materials (Fe-Al)." They discuss how welding technologies were developed for specific families of materials followed by the joining of dissimilar materials and how such technologies are implemented in the automotive industry.

Next, Mike Miles et al. describe efforts in modeling material deformation of advanced high-strength steels joined by friction stir spot welding. This work combines heat input from deformation as well as frictional heating from the welding process and relates processing parameters to microstructure and deformation behavior. The model was validated with experimental data and accurately predicted nugget geometry and thermal profiles.

Third, Q. Pang et al. present an example of forming joined materials in "Deformation Characterization of Friction-Stir-Welded Tubes by Hydraulic Bulge Testing." Here they discuss hydraulic bulge forming of thin-walled aluminum tubes that were joined by a novel combination of friction stir welding with spin processing.

Hande Güler provides insight into a friction stir spot welding method to join aluminum sheet metals and the post-joining behavior of the material in "The Mechanical Behavior of Friction-Stir Spot-Welded Aluminum Alloys." This is followed by an experimental investigation into the joining of mixed materials: aluminum and stainless steel with a technique presented by Feng Li et al. in "Experiment on the Reliability of Aluminum-Stainless Steel Joints by Cold-Pressing Joining."

Finally, in "Bulk-Forming Simulation of Bimetallic Watchcase Components," Ting Fai Kong and Luen Chow Chan take a different approach to this topic and present a numerical/experimental study on deformation of bulk materials in the joining and forging of aluminum with stainless steel.

These articles illustrate different approaches to investigating the deformation behavior of welded or joined structural materials including dissimilar materials that will be increasingly implemented in many industries in the future. A symposium will be organized on this topic at the Material Science and Technology 2015 Conference titled "Deformation and Forming of Joined Structures."

John E. Carsley is the guest editor for the Shaping and Forming Committee of the TMS Materials Processing & Manufacturing Division, and coordinator of the topic Deformation and Formation of Joined Materials in this issue.

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The following articles being published under the topic of Deformation and Formation of Joined Materials provide excellent details and research on the subject. To download any of the papers, follow the url http://link.springer.com/journal/11837/66/10/page/1 to the table of contents page for the October 2014 issue (vol. 66, no. 10):

- "Welding of Very Dissimilar Materials (Fe-Al)," Judy Schneider and Ron Radzilowski.
- "Temperature and Material Flow Prediction in Friction Stir Spot Welding of Advanced High-Strength Steel," M. Miles, U. Karki, and Y. Hovanski.
- "Deformation Characterization of Friction-Stir-Welded Tubes by Hydraulic Bulge Testing," Q. Pang, Z.L. Hu, X. Pan, and X.Q. Zuo.
- "The Mechanical Behavior of Friction-Stir Spot-Welded Aluminum Alloys," Hande Güler.
- "Experiment on the Reliability of Aluminum-Stainless Steel Joints by Cold-Pressing Joining," Feng Li, Xiao Chong Sui, Xin Xin Guo, and Hong Bin Dai.
- "Bulk-Forming Simulation of Bimetallic Watchcase Components," T.F. Kong and L.C. Chan.