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This report describes the improvement in the joint properties of friction welded joint of 780MPa-class high tensile steel. Welded joint made by a continuous drive friction welding machine (conventional method), had not obtained 100% joint efficiency in spite of applying forge pressure. This was due to the softening of the welded interface zone for heat input during braking times. Therefore, we developed a continuous drive friction welding machine with an electromagnetic clutch to prevent heat input during braking time. We proposed the process as "The Low Heat Input Friction Welding Method (The LHI method)." In this case, the joint had the same tensile strength as the base metal at friction time when the friction torque reached the initial peak torque. That is, the welded joint obtained 100% joint efficiency by using only the friction stage up to the initial peak torque without the forge (upsetting) stage, despite the existence of a slightly softened region adjacent to the welded interface. Furthermore, the softened region was hardly generated, when this joint was made by applying forge pressure at the initial peak torque. As a conclusion, a welded joint of high tensile steel made by only the friction stage of the LHI method had excellent joint properties. The LHI method has a lot of advantages for joining materials such as super fine grain steel that have many problems in conventional fusion welding processes.

SUP-01: The Potential of Superplastic Materials in Manufacturing: The Case of Al-Mg Alloys

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Superplastic forming (SPF) has recently made the transition to largescale, mass production operations with the advent of the Quick-Plastic Forming (QPF) process. The success of superplastic aluminum-magnesium alloys in this process is a result of several important material behaviors and the development of improved quantitative, predictive understandings of these behaviors. Key among these are the deformation mechanisms of grainboundary sliding (GBS) and solutedrag (SD) creep and the failure mechanisms of cavitation and flow localization. The current understanding of these behaviors and their practical influence on SPF and QPF operations are discussed with respect to AA5083 commercial alloys. Challenges to improving the predictive understanding of behaviors in this alloy class are described. The importance of improved predictive understandings for further alloy development, thermomechanical process development, and forming process design are outlined. The potential for further improvement in this material system is discussed, as well as how lessons learned from the recent successes with this material system can be used to unleash the potential of other superplastic material systems.

SUP-03: Low-temperature Superplastic Forming in Zn-22mass%Al Alloy and its Application on Maintenance Free Seismic Damper

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It has been reported that Zn-22mass%Al alloy with ultra-fine grained microstructure had a potential for exhibiting the more stable seismic response than that of conventional seismic damping material, i.e., low-yield-point steel, lead and rubber. However, the new seismic damper was applied only in a limited way because the production of the large bulky materials with ultra-fine grained microstructure and forming to the device shape were difficult technology and high cost. In order to reduce the cost of the seismic device, therefore, a near-net shape forming process by superplasticity was utilized. At first, we designed the most appropriate damper’s shape for a general residence by carrying out finite element method simulation and the simplified shaking test of the machined various samples with different dimension. Before an actual forming, in addition, we predicted the formability of this alloy by finite volume method simulation, where the material properties obtained by tensile testing were incorporated. The simulation results confirmed that the strain was concentrated at a particular section. However, a mechanical properties and microstructure after an actual forming at the same section retained those before the forming. Finally, we researched the performance by full-scale shaking testing, where the formed dampers were mounted in the frame of the house. From the result, we confirmed that the quake of the frame with dampers reduced four times from that without dampers.

SUP-04: Cavitation Behavior in Low-temperature Superplastic Zn-22mass%Al Alloy

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Recently, it has been reported that Zn-22mass%Al alloy exhibit superplastic behavior even at room temperature and high-strain-rate of 102 s-1 and could possibly be applied to a new seismic damper. In addition, an attempt to utilize a near-net shape forming technique by low-temperature superplasticity has been carried out in order to achieve mass-production and to reduce the damper’s manufacturing costs. By now, almost the reports discussed only the cavitation behavior in Zn-22mass%Al alloy superplastically deformed at high temperature above 473 K, and the quantitative analysis was also carried out scarcely. Then, the cavitation behavior in Zn-22mass%Al alloy superplastically-deformed at room temperature and high temperature of 473 K was investigated quantitatively. As the results of cavity volume analysis in samples deformed at 473 K and room temperature, the macroscopic cavity growth rate at 473 K was lower than that at room temperature. In addition, the quantitative analysis about cavity number confirmed that the total number of cavities deformed at 473 K was smaller than that at room temperature at all strain. The number of cavities deformed at 473 K increases with strain as well as the traditional cavity behavior. On the other hand, the number of cavities deformed at room temperature was roughly constant during straining and most of cavities were nucleated in the primary stage of deformation. Also, the cavity growth rates for the cavity with the radius of above 1 mm in both deformation conditions were almost identical.

SUP-05: Flat Cavities Formed in Superplastically Deformed 3Y-TZP and Their Effect on Elongation

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Cavities can be formed and grown in polycrystalline materials subjecting to superplastic deformation. Cavitation in the polycrystalline materials is one of the phenomena relating to the mechanism of superplastic deformation. In the yttria stabilized tetragonal zirconia polycrystals (Y-TZP) deformed under a high strain-rate or a low temperature superplastic condition, the formation of crack-like flat cavities having very small gaps lying mostly normal to the tensile axis was found by means of a small angle neutron scattering. The generation of these flat cavities seemed responsible for the apparent strain softening appeared in the stress-strain curve. The growth and coalescence of the flat cavities were related to the formation of brittle-like cracks, which would lead to an earlier fracture without apparent occurrence of necking, resulting in the decrease in the total elongation, i.e., the formation of the flat cavities seemed to be a