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Sagging Resistance of Warm Formed Aluminum Brazing Sheet

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Abstract Interrupted tensile tests, performed between room temperature (RT) and 250°C, were used to simulate warm forming of an AA3003/AA4045 brazing sheet. Brazing performance was predicted from sagging distance measurements after a thermal cycle. The sagging distance as a function of strain for sheets strained at 150°C was similar to that of RT strained samples, while the sagging distances were large at all levels of applied strain for sheets strained at 200°C and 250°C. Large sagging distances were correlated with the occurrence of liquid film migration during simulated brazing and a recovered substructure in the core alloy, while small sagging distances were associated with a coarse, recrystallized core alloy. The poor brazing performance of sheets formed above 150°C was proposed to be due to a reduction in work hardening during forming, resulting in a recovered, rather than recrystallized, microstructure which is susceptible to liquid film migration.

Keywords: Warm Forming, Brazing, Sagging Distance, Liquid Film Migration (LFM), Recrystallization, Strain Induced Boundary Migration (SIBM)

1.0 Introduction

Since the 1970's, automotive heat exchanger production has largely been achieved by controlled atmosphere brazing of aluminum (Al) alloy sheets and tubes, as vehicle producers sought cost and weight savings (Zhao & Woods, 2013). During production, Al brazing sheets are formed to the required geometry, assembled with other components, and are passed through a brazing furnace. The Al sheets are multi-layered, consisting of at least two Al alloy layers. The core layer is often a manganese (Mn)-rich AA3xxx series alloy, which provides strength to the assembly, while the clad layer is a silicon (Si)-rich AA4xxx series alloy. The high Si content of the clad alloy sufficiently depresses the melting temperature such that, during brazing, the clad alloy is either partially or fully liquid, while the core alloy remains solid. After removal from the furnace, the assembly is fully joined, with the re-solidified clad alloy serving as the filler metal for the brazed joints.

Unfortunately, as noted by Bolt et al. (2001) cold rolled Al alloy sheets are known to have relatively poor formability compared with other conventional materials used in automotive applications, such as sheet steel. As noted by Zhao and Woods (2013), Al alloy sheet deformation continues to be a concern for heat exchanger manufacturers as they strive to use progressively thinner sheets. Warm forming, where sheets are heated to below their