COMPARATIVE STUDY OF ALUMINUM JOINT STRENGTH AND DURABILITY WITH VARYING THICKNESS, BOEHMITE-TYPE OXIDE-surfaces

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The presence of boehmite oxide on aluminum surfaces has often been associated with weather-durable bonding. In this work, a considerable variance was shown in aluminum joint durability involving such oxide surfaces with varying thicknesses as generated in the absence or presence of electrolyte in boiling water; i.e., deionized or tap water. The changes in oxide were generated starting from a deoxidized surface base by varying the exposure times in boiling water.

Joint strengths tended to decrease with increasing oxide thickness; i.e., longer exposure times, and could be as much as 50 percent lower in strength than the deoxidized surface control joints. Variable durability patterns resulted from varying weathering conditions; also, when stress was simultaneously imposed.

Bonding to deionized water-produced oxide surfaces showed enhanced durability using unstressed joints in strictly water-soaking conditions or corrosive salt fog cycle exposures. Durability generally increased as the oxide buildup in deionized water increased and was inversely related to initial joint strength. In addition to generally lower durability in these exposures, the tap water-produced oxide bonds had a different pattern, peaking in durability after ten minutes' exposure.
With simultaneously imposed stressing conditions, the tap water-produced oxide surface joints assumed the greater durability. These joints peaked in durability with the five-minute generation oxide condition. Performing overall with lower durability potential, the deionized water-produced oxide joints had their best response at ten-minute oxide generation level.

Very favorable durability responses were found for these predominantly boehmitic oxide-type compared to similarly fabricated and tested joints reported by Alcoa using acid deoxidized, and chromic or phosphoric-acid-anodized 6061-T6 adherends.

This procedure could have some practical application for low-cost general manufacturing operations where the simple boiling water bath treatment would be replacing more expensive aerospace-type surface preparations, like modified FPL and chromic or phosphoric acid anodizing procedures.

INTRODUCTION

Wegman et al.\textsuperscript{1,2} studied how the oxides on 2024-T3 aluminum affect the bond strength of joints by deoxidizing the adherend in hot sulfuric acid-sodium dichromate solution and establishing that a new oxide developed after immersion in hot deionized or tap waters. Low joint strengths and adhesive-type failures resulted when bonding to the former. High joint strengths and cohesive-type failures were found with the latter treating conditions. They concluded that a thick, hydrated, cohesively weak surface oxide formed in deionized water from which strong bonds could not be obtained. The slight acidity present that promotes multivalent compounds in tap water was said to prevent generation of this hydrated layer. No durability test data were offered in these investigations. More recently other investigators, among them Wu and Bowen\textsuperscript{3,4}, have attached specific significance to generating the boehmite form of oxide for most durable bonding with high initial strengths. It is the intent of this investigation to study some aspects of both considerations by studying the bond durability of joints fabricated with surfaces generated from either hot deionized or tap water immersion processing. The water temperature was deliberately maintained at 100°C (212°F) in order that any oxide generated would essentially be the boehmitic type. Additional variances from the Wegman work included substitution of 6061-T6 for 2024-T3 alloy and deoxidizing in hot caustic (Alcoa 1 Process) instead of sulfuric acid-sodium dichromate solution. Finally, because Russell and Garnis\textsuperscript{5} had demonstrated significant differences in joint strength after varying water rinse conditions, a decision was made to study the boehmite generation effects using a range of water-exposure times.