December 1968 Brief 68-10561

NASA TECH BRIEF

Weld Joint Strength and Mechanical Properties in 2219-T81 Aluminum Alloy

A literature search was performed on standard industry practices in the welding and inspection of 2219-T81 aluminum alloy. After the literature search was completed, welding was done by industry standard methods on 0.063-inch sheet and 1.0-inch plate material. Mechanical properties, static fracture, and cyclic flaw growth tests were performed on the base material, welded, and repair welded sheets and plates.

The plate and sheet were welded using automatic TIG (tungsten-inert gas) weld techniques and manual repair weld techniques. The fracture characteristics were studied at room temperature, −320°, and −423°F by locating notches and cracks in the parent material, heat-affected zone (HAZ) fusion line, and the center of the weld metal. Mechanical properties of the various zones were obtained by tensile tests utilizing small strain gages.

Welding caused a large reduction in yield strength for 2219-T81 sheet and plate but only a modest reduction in ultimate strength. In general, the static toughness properties of the base material sheet and plate increased with a reduction in temperature. However, the toughness in the center of the weld showed a significant decrease between −320° and −423°F in both plate and sheet.

Also shown by the tests was that cyclic crack or flaw growth for 2119-T81 is somewhat erratic for automatic welded material and is very erratic for repair welded material.

Summary of Results

1. The yield strength of 2219-T81 sheet and plate decreases significantly when welded. The reduction of yield strength is much greater than the corresponding reduction in ultimate strength.

2. Base metal 2219-T81 sheet and plate toughness increases with a decrease in temperature. Plane stress and plane strain fracture toughness of the HAZ increases with a decrease in temperature; the HAZ is less tough than the base metal but tougher than any other zone. The weld metal region has the lowest fracture toughness of any of the regions tested.

3. The weld area fracture toughness (plane stress or plane strain) of automatic welded 2219-T81 sheet or plate decreases significantly between −320° and −423°F.

4. The behavior of welded 2219-T81 aluminum plate is quite erratic after three repair welds have been made. The toughness values of repair welded 2219-T81 aluminum can be substantially lower than those of the new welds.

5. Cyclic flaw growth rates are generally higher on the weld metal than any other region tested.

6. At normal operating stresses, the critical flaw size for 2219-T81 parent metal and welds is quite large ($a \approx 1/2$ inch, $2c \approx 2$ inches) given the standard 2:1 weld land buildup.

7. Due to the very low possible toughness of repair welds, it is recommended that repair welding be kept to a minimum with 2219-T81 aluminum as serious material property degradation is possible. All repair welds (except for the flaw simulation tests) on this program meet all government specifications for welds and would be fully acceptable in an aerospace vehicle.

(continued overleaf)

8. Tungsten inclusions appear to reduce the fracture toughness of the welds quite considerably and thus should always be removed.

9. Documentation for the innovation is available from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Price $3.00
Reference: B68-10561

Technical Questions concerning the innovation may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B68-10561

Patent status:

No patent action is contemplated by NASA.

Source: W. E. Witzell and C. J. Kropp
of General Dynamics/Convair
under contract to
Lewis Research Center
(LEW-10479)