NASA TECH BRIEF

Hot-Cracking Studies of Inconel 718 Weld-Heat-Affected Zones

Inconel 718, a commercial, high-strength alloy, has been considered the most weldable of the precipitation-hardened, nickel-base alloys. The gas-tungsten-arc, gas-metal-arc, and electron beam welding processes have all been used, and many of the resultant Inconel 718 components include the largest commercial forgings available today. The extensive welding associated with these forgings, however, has introduced potential problem areas. The physical and mechanical metallurgy of the large mass complicates the joining of the material. Although the common problem of the nickel-base, precipitation-hardened alloys has been postweld heat-treat cracking, Inconel 718 is subject to weld-heat-affected zone hot cracking which appears to be primarily heat oriented and aggravated by large grain size.

To better understand and correlate the weldability (resistance to hot cracking) of Inconel 718 with respect to chemical, mechanical, and metallurgical factors, a program was established to conduct hot ductility tests, gas-tungsten-arc fillerless fusion tests, and circle patch-weld-restraint tests on the alloy. This study covered numerous Inconel 718 heats from several mill sources and in various section sizes and part configurations. The experiences associated with shop welding problems were compared to laboratory test results. A correlation of the test results with composition, heat-treat condition, grain size, and microstructure was attempted. The study included a comparison of "poor weldability" Inconel 718 to "weldable" Inconel 718.

Results indicate that:

1. The elevated temperature ductility of Inconel 718 materials varies, not only from heat to heat, but for a given heat depending upon mill processing.
2. Inconel 718 is subject to weld-heat-affected zone microcracking. The incidence and severity are directly related to the permanent impairment of original elevated temperature ductility suffered after exposure to a thermal cycle involving a degrading peak temperature.
3. The weld-heat-affected zone microcracking is associated with the formation of low-melting, intergranular films as a result of exposure to a temperature range of 2100° to 2200°F.
4. Proper mill processing procedure can minimize the undesirable effects of these low-melting grain boundary films, principally through control of grain size and secondary phase morphology.
5. Hot ductility and fillerless fusion laboratory tests both proved capable of measuring the weld fabrication characteristics of Inconel 718 mill products, although the hot ductility test is preferred.
6. Weld circle patch test data were insufficient to evaluate the merit of this weldability test.

Notes:

1. The testing procedures used in the study can be applied to determine the relationship of the chemical and thermomechanical history of a weld to the presence of microfissures in the weld.
2. Documentation is available from:
   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 21151
   Price $3.00
   Reference: TSP69-10052

Patent status:

No patent action is contemplated by NASA.

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