

WELDABILITY OF IRON ALUMINIDES

G.M. Goodwin, P.J. Maziasz, C.J. McKamey, J.H. DeVan, V.K. Sikka

Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6096

RECEIVED
SEP 23 1984
OST-1

ABSTRACT

Corrosion-resistant weldable iron aluminide alloys are being developed for weld overlay cladding of conventional steels and alloys and possible structural applications.

Weld hot cracking can be minimized by careful choice of alloying additions, and hot cracking resistance equivalent to commercial austenitic stainless steels has been achieved. Hydrogen-induced cold cracking, however, continues to be a problem with these alloys, both in monolithic weldments and weld overlay cladding applications.

We have found that preheat and postweld heat treatment can reduce hydrogen cracking, and that composition is also an important variable. Experiments in controlled atmospheres have confirmed that a major source of hydrogen is provided by the reduction of water vapor from the environment, and that oxygen helps to reduce cracking sensitivity.

Concurrently, we are developing filler metals using the aspiration-casting process, for use both as filler metals with the gas tungsten arc process, and as core wire for the production of shielded metal arc electrodes.

DISCUSSION OF CURRENT ACTIVITIES

Hot Cracking

Initially one of the commonly occurring problems with these alloys, hot cracking is no longer considered to be a major concern. Certain compositional effects must, however, be kept in mind; carbon and boron are beneficial within limits, and niobium, molybdenum, and zirconium can be deleterious at higher levels. Figure 1 summarizes sigma_{ij} hot cracking, test results for a number of iron aluminide compositions, compared with similar data for other alloys. As noted from the figure, by careful selection and control of composition, we have been able to achieve hot cracking resistance equivalent to some commercial heats of austenitic stainless steels.

This research was sponsored by the Fossil Energy Advanced Research and Technology Development (AR&TD) Materials Program, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

"The submitted manuscript has been authored by a contractor of the U.S. Government under contract No. DE-AC05-84OR21400. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes."

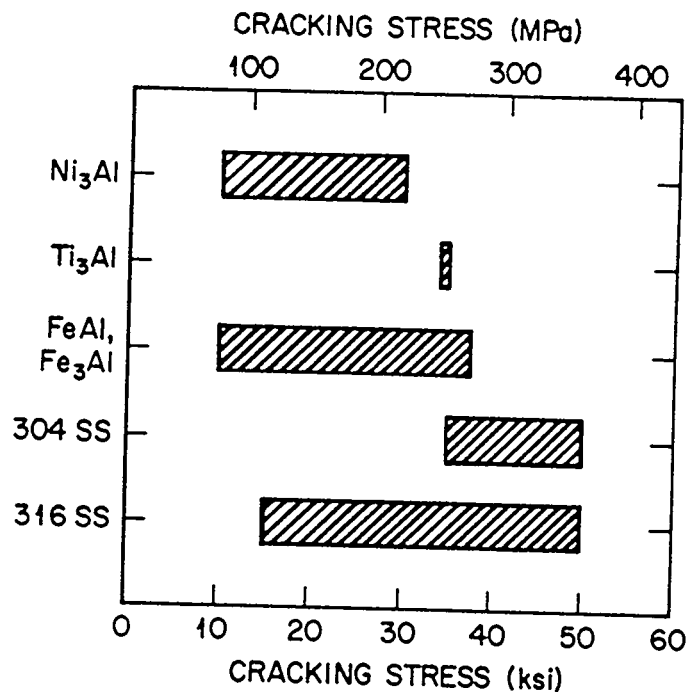


Fig. 1. Summary of sigma-jig test results

Cold Cracking

Hydrogen induced cold cracking continues to be a problem with these alloys; we are studying cold cracking sensitivity using two approaches, *viz.* welding of monolithic thin sheet in controlled atmospheres, and, concurrently, development of aspiration-cast filler metal for weld overlay applications.

Welding of Thin Sheet in Controlled Atmospheres

To evaluate cold cracking in thin sheet material, we are using the sigma-jig test fixture in a controlled atmosphere chamber, as shown in Figure 2. After welding, transverse stress is applied as in hot crack testing. The chamber can be evacuated to approximately 10^{-5} torr and backfilled with high purity inert gas; total oxygen and water vapor as impurities can be maintained at less than 50 ppm by volume. Controlled amounts of oxygen and/or water vapor can be added as desired. A single heat of a "simplified" Fe₃Al alloy (FA-185) has been used for all of the controlled atmosphere tests; its composition is 16% Al - 5% Cr - 0.1% C, balance iron (weight %).

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

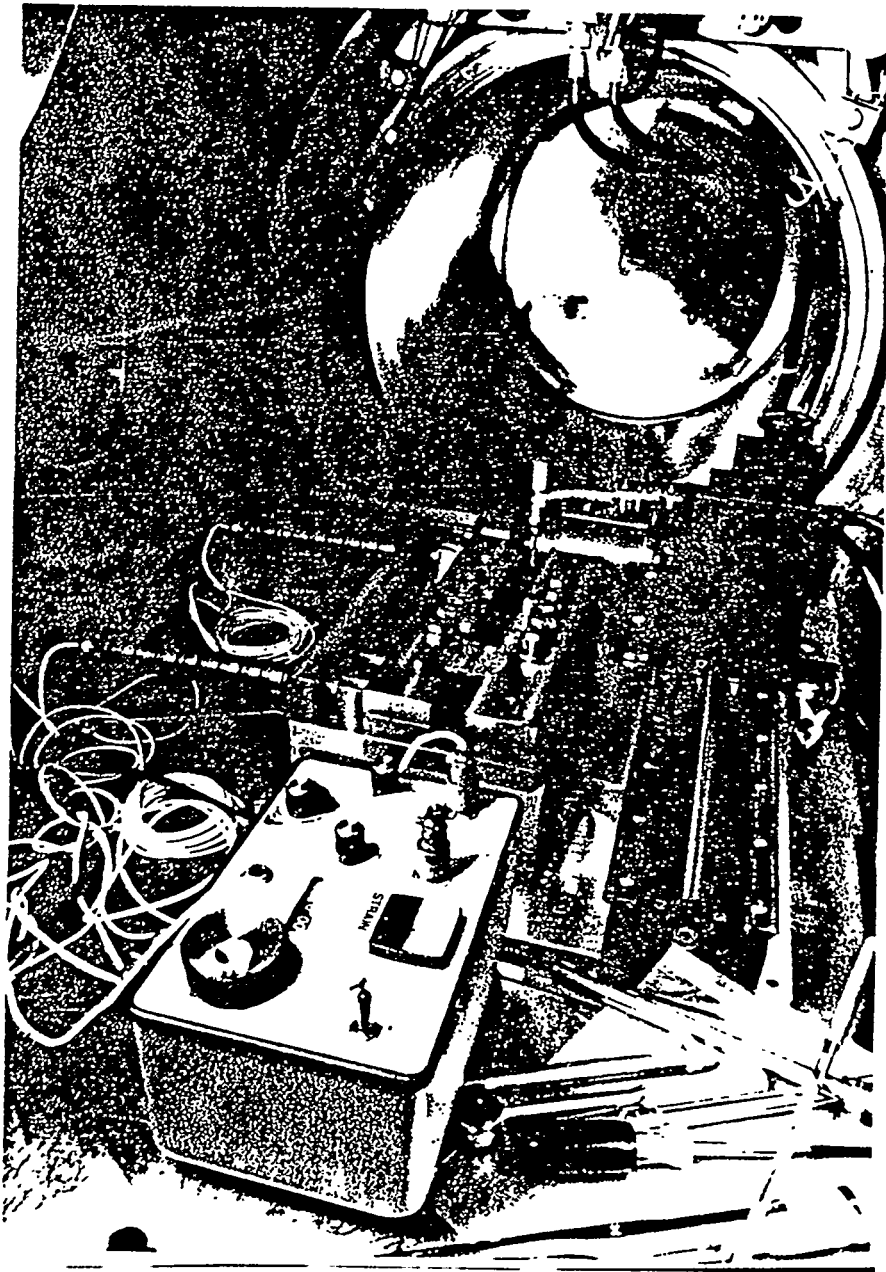


Fig. 2. Sigmajig test fixture installed in controlled atmosphere chamber

Tests to date have shown:

- when welded in pure argon, no cold cracking occurs, even at post-weld stresses of approximately 20 ksi (138 MPa);
- when welded in argon-hydrogen mixtures ($\leq 2\% \text{ H}_2$), cracking occurs at intermediate stresses [8-16 ksi (55-110 MPa)]; and
- when welded in argon-water vapor mixtures, cracking occurs at low stresses [$\leq 8 \text{ ksi}$ (55 MPa)].

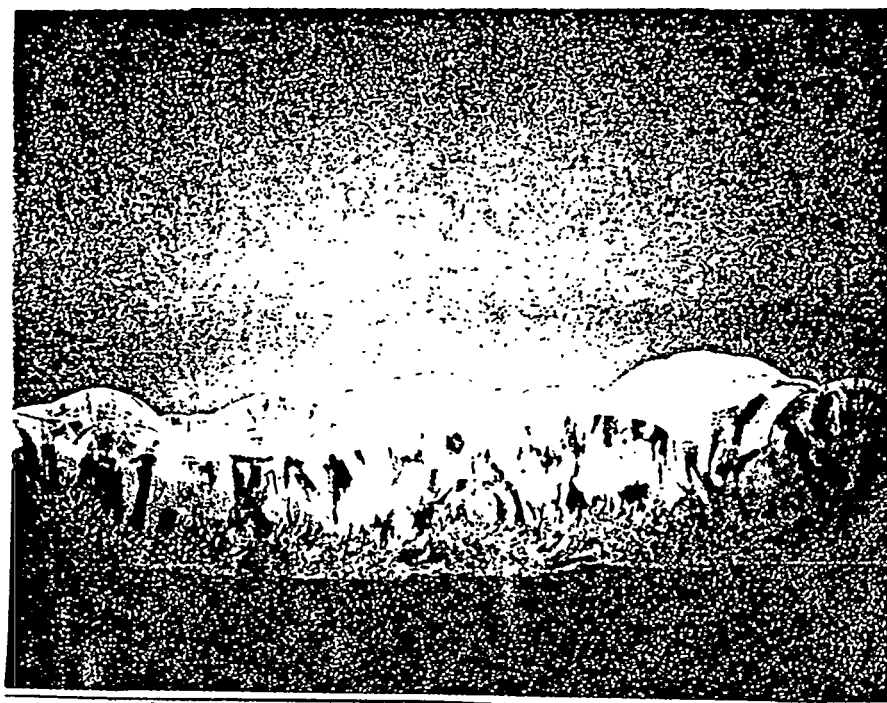


Fig. 3. Iron aluminide weld overlay on 2 1/4 Cr - 1 Mo base plate using the gas tungsten arc (GTA) process. (magnification: 3.5x)

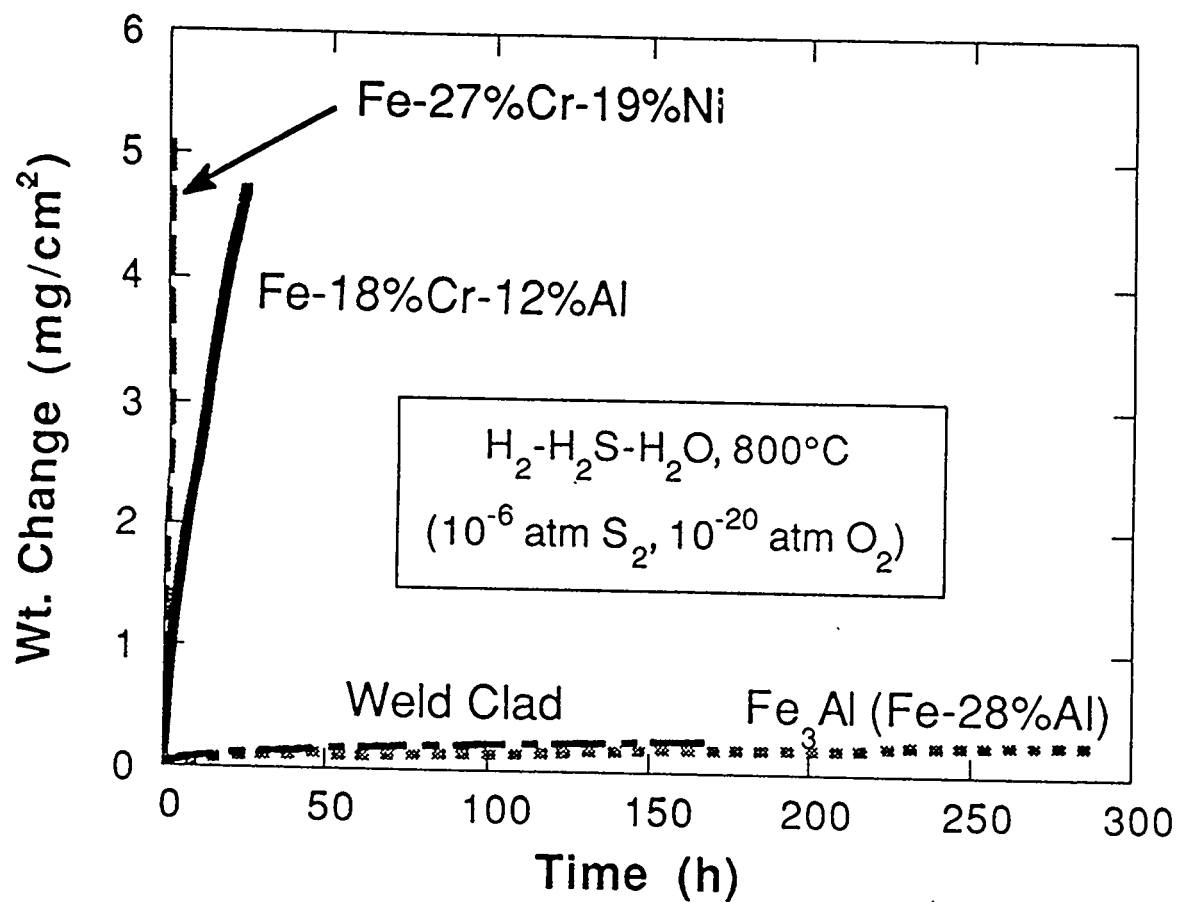


Fig. 4. Weight gain vs. time for several alloys in a simulated coal gas environment

CONCLUSIONS

From our studies to date, we can conclude:

- Hot cracking: occurrence is highly variable and needs continuing consideration; can be as good as some austenitic stainless steels. It is strongly affected by compositional effects.
- Cold cracking: its occurrence is still a concern requiring further study. It is currently only avoided by special measures including preheat and postweld heat treatment, and may limit structural applications of these alloys.
- Filler metal development: welding consumable production using the aspiration-casting approach needs additional development, but appears feasible.
- Environmental testing: developmental overlay clads can perform as well as wrought material in simulated coal gas environments at 800°C.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.