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WELDABILITY OF IRON ALUMINIDES

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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 ocurring 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 sigmajig 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.

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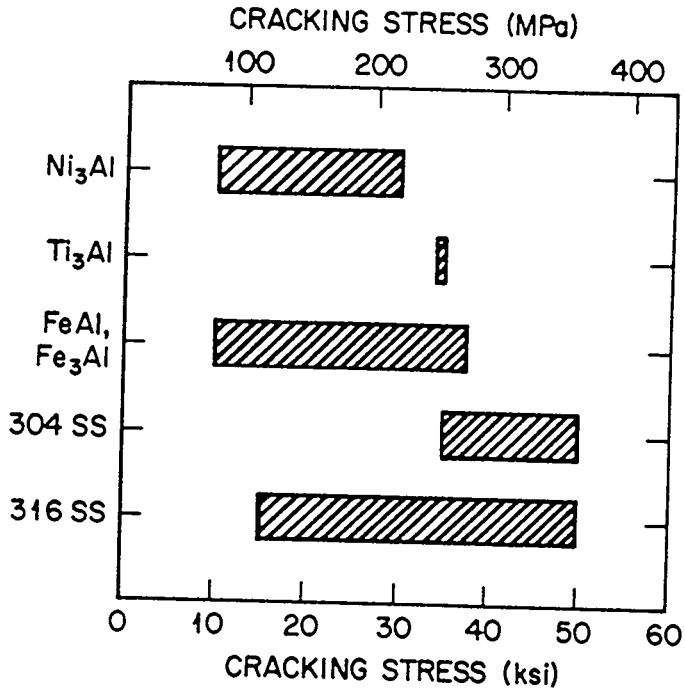

Fig. 1. Summary of sigmajig test results

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 sigmajig 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" Fe_3Al 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 %).

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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% 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 ksi(55 MPa)].

Fig. 3. Iron aluminide weld overlay on 2¼ Cr - 1 Mo base plate using the gas tungsten arc (GTA) process. (magnification: 3.5x)

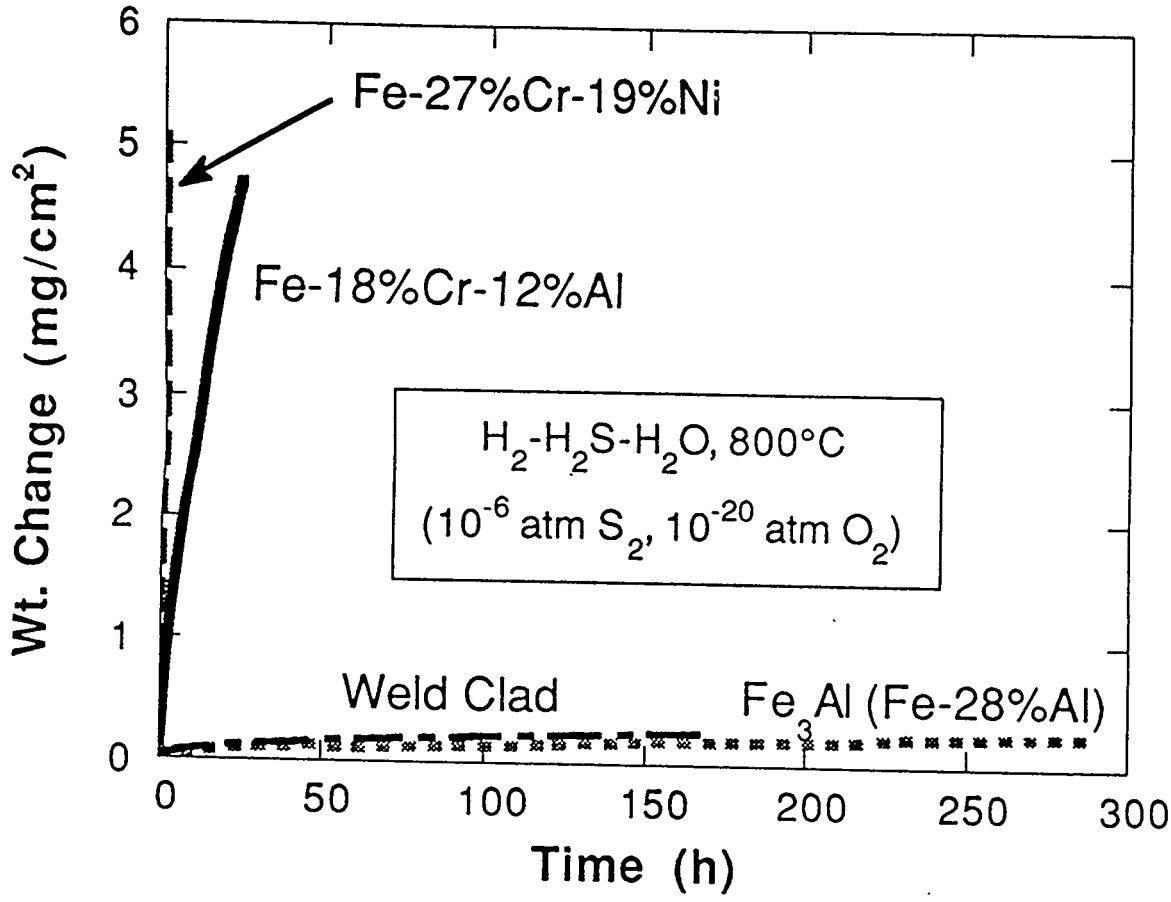

Fig. 4. Weight gain vs. time for several alloys in a simulated coal gas environment

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.