Cold Work Embrittlement of Interstitial-Free Steels

Understanding CWE can reduce steel fractures during secondary deformation

Interstitial-free (IF) steels are defined by their low amounts of solute interstitial elements, such as carbon and nitrogen. During secondary forming, strain can be localized at the grain boundaries of these steels, resulting in secondary cold work embrittlement (CWE).

Limited understanding of CWE has inhibited steel and parts manufacturers from accurately predicting the sensitivity of IF steels to CWE. Manufacturers need this information to reduce the occurrence of fractures during secondary deformation and to improve the in-service reliability of parts.

This project sought to develop a standard, reliable methodology that determines the exact effect of CWE on the performance of IF steels. It evaluated the influence of steel chemistry and processing conditions, microstructure, and test conditions on CWE as well as CWE's effect on fatigue properties—specifically in the as-rolled and high strain, deep drawn conditions. Researchers selected an IF steel known to be susceptible to CWE and conducted fatigue tests for both as-rolled and deep drawn conditions. In the deep drawn conditions, two orientations were investigated: transverse and parallel to the major strain direction. Detailed metallography and fractography related crack formation appearance with microstructure/forming strain.

Among their findings, researchers discovered that the fatigue strain/life behavior of the as-rolled condition is consistent with other IF and non-IF sheet steels, and that fatigue cracking is initiated at the as-rolled or deep drawn surface. Researchers recommend further testing of the deep drawn condition in non-CWE sensitive steels to determine if CWE has an effect on fatigue performance in deep drawn IF sheet steels.

View of an oil pan showing cracking of a flange created during secondary forming operations

Benefits for Our Industries and Our Nation

- Enables steel producers to increase supply of medium-strength IF steel
- Reduces the occurrence of fracture during secondary deformation
- Produces more reliable, lighter weight cars
- Improves environmental impact due to automobile weight reduction

Project Participants:

MTL/CANMET
(Principal Investigator)

American Iron and Steel Institute
(Project Manager)

AK Steel Corporation

Dofasco, Incorporated

LTV Steel Company

National Steel Corporation

Rouge Steel Company

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PROJECT PLANS AND PROGRESS:

- Completion of two reports on a company and literature survey on CWE test methods (September, 1998).
- Development of a test procedure for the 150-mm cup/expansion test (September, 1998).
- Production and delivery of seven steels for the parametric study (April, 1999).
- Production and delivery of five steels for the fatigue study and for the fabrication of real parts (June, 1999).
- Fabrication of real parts using low and high sensitivity steels for impact testing in laboratory (July, 1999).
- Stamping of deep-drawn parts for production of pre-strained specimens for the fatigue study (August, 1999).
- Completion of the parametric study on the effect of strain, cup edge condition, specimen size, impact speed, steel chemistry, and sheet thickness (February, 2000).
- Completion of the impact tests on real parts (April, 2000).
- Dissemination of preliminary results at the Mechanical Working and Steel Processing Conference in Toronto (October, 2000).
- Draft report on correlation between laboratory test results and fracture in real parts (October, 2000).
- Final report on CWE study (March, 2001).
- Completion of fatigue tests on prestrained specimens (January, 2001).
- Final report on fatigue (March, 2001).

Steel Program

The Steel Industry of the Future (IOF) subprogram is based in the Industrial Technologies Program (ITP) within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. The subprogram works with the steel industry to promote development of more energy-efficient and environmentally sound technology for steel processing. Guided by industry-identified research and development priorities, ITP's steel portfolio addresses those priorities that offer the greatest potential for energy savings in cokeless ironmaking, next-generaton steelmaking, and yield improvement. To learn more about Steel IOF activities, visit the program web site at: www.eere.energy.gov/industry/steel/

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