MATERIALS RESEARCH SEMINAR
Thursday, Sep 11, 2008, 4:00 PM, HH 202

Carbide Stability and Evolution in Cr-Mo Steels Used in Power Generation Plants

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Abstract

In the past century the power industry expanded greatly; to-date, many of those the power plants have already been in service for forty, fifty years, exceeding their original design life. It is not uncommon to find Cr-Mo steels based power generation equipment that has accumulated lives of 200,000 to 300,000 hours. Such long periods of operation at elevated temperatures can cause profound changes in material microstructure as well as performance deterioration. Under common boiler operating conditions, aging occurs in the Cr-Mo steels with carbon migration that affects the sequence of carbide formation in the ferritic matrix.

To learn about the stability and evolution of carbides, T22 steel tube samples were heat treated to different temperature and time conditions, determined according to Larson-Miller analysis, to simulate different service history with service times varying between 50,000 and 350,000 hours at 564^{o}C. To maximize the number of carbide precipitates examined, a selective digestion method was used and then, the carbide particles collected were analyzed using X-ray diffraction. Steel samples were also examined using electron microscopy. In addition, microstructural changes or Cr-Mo steels upon aging were analyzed, e.g. ferrite grain size, carbide size and spatial distribution, carbide number density, and the size of the precipitation denuded zones next to ferrite grain boundaries. The precipitation of carbides begins with the formation of cementite (Fe_3C), followed by a number of alloy carbides (Mo_2C, Cr_7C_3, Mo_7C_3, $Mo_{23}C_6$, and Mo_6C) as the system tends towards equilibrium. It is well accepted that initial carbide precipitation strengthens the microstructure for high temperature creep resistance. Prolonged thermal exposure, however, may lead to coalescence and ripening of the precipitates that decrease their ability in strengthening the alloy. The nature and sequence of carbide precipitation influences the mechanical properties of the steel and their failure characteristics. Cold fracture of the samples allowed for fractographic analysis that related microstructure with fracture mode.

About the Speaker

Dr. Juan Carlos Madeni is a Research Associate at the Center for Welding, Joining and Coatings Research at the Colorado School of Mines and lectures in the Metallurgical and Materials Engineering department. He first studied Civil Engineering at the University Tomas Frias in Bolivia (1994), the same year his academic ambitions brought him to the US under the Andes Scholarship for Academic Excellence. Dr. Madeni obtained a B.Sc. and M.Sc. degrees in Metallurgical and Materials Engineering, and later a Ph.D. (2006) in Materials Science at the Colorado School of Mines. His research activities include design of wire consumables for welding, explosive cleaning for oxide removal in power plant boiler tubes, and dissimilar metal joining. Dr. Madeni conducts studies on wetting and spreading, and filler metal flow in the microscale; and has developed an extensive database for lead-free solder alloys and its properties.

Soft drinks and snacks served in the classroom prior to the presentation.

Materials Science Program **Metallurgical and Materials Engineering Department**