Corrosion Studies in Ultra-Steel Project at NIMS in Japan

Since 1997, the National Institute for Materials Research (NIMS, formerly National Research Institute for Metals) in Japan has promoted a project for R&D of innovative steels, under the name of Ultra-Steel. The project covers such fields as 800MPa class steels for welding construction, 1500MPa ultra-high strength steels resistant to hydrogen brittleness, advanced heat resisting steel for ultra-super critical power plants and advanced corrosion resistant steels for marine environments. About 80 fulltime scientists and 30 guest researchers are engaged in the project. Most of the guest researchers are from iron and steel companies and heavy industries. An annual budget of 2,000 M yen has been allocated by the Ministry of Education, Science, and Technology, excluding personnel expenses.

The principal concern in the marine corrosion studies is on the development of new stainless steels and coatings that show corrosion resistance in splash and submerged zones, and low alloy weathering steels usable without painting in a coastal atmosphere.

Materials Creation in Corrosion Resistant Steels

In the creation of new stainless steels highly resistant to marine corrosion, the focus has been placed on the cleanliness of steels and nitrogen addition. For attaining high content of nitrogen in steels, a system of pressurized electroslag remelting has been developed, in which a 316 L stainless-steel rod was melted by Ohmic heating through the slag layer under a pressurized N_2 atmosphere of 1 to 4 MPa to form a 20 kg ingot. The high-N (1-1.5%) and low-Ni (0-4 %) austenitic stainless steels showed high strength of 1300 MPa and very high resistance to localized corrosion in seawater. The new high-N stainless steels are immune to crevice corrosion at 35°C and at very noble potentials as high as that of dioxygen evolution in artificial seawater.

Joining and Surface Coating Study

High-N steels suffer from damages and degradation following melting and heat cycles during welding such as blowhole formation at the joints and sensitization at the heat affected zone. The higher nitrogen solubility of the filler such as 30Cr-20Ni-5Mo-Fe prevents the formation of N_2 bubbles at the joints by absorbing the released nitrogen. The welded part showed a pitting potential as high as that of substrate metal when a high alloy filler was employed.

Spray coating may prove to be a promising technique for surface coating that may replace titanium cladding. A high velocity oxy-fuel spray method has been developed in which high velocity particles are sprayed at relatively low temperatures resulting in the formation of pore-free films with improved adherence. Samples coated with pore-free films retain a higher potential after prolonged immersion in seawater.

Evaluation of Atmospheric Corrosion and Development of Low-Alloy Steels

The development of acceleration tests was initiated from a very basic standpoint: phenomenological but nanoscale analysis of water condensation on metal surfaces and rust nucleation on metal surfaces. The conventional scanning probe microscopes are applied to *in situ* corrosion measurements under wet/dry conditions. Moreover, a new technique of super Kelvin force microscopy (SKFM), which can measure the profile and potential of wider areas ranging from nanometers to centimeters, has been developed. Using SKFM, it has been demonstrated that corrosion proceeds by the repetition of the transfer of chloride ion to form $FeCl_2$ at the corrosion front and the subsequent absorption of water.

In Japan, where a higher population is segregated in coastal zones, the high demand is for chloride-resistant weathering steels. Detailed analysis of alloyed elements in weathering steels have been carried out from the viewpoints of colloid chemistry and thermodynamics of double oxide formation, and the characterization, electrochemistry, and material transport of rust. For macroscopic evaluation of atmospheric corrosion, a high-accuracy testing facility for atmospheric test was installed within NIMS.

NIMS will host the First International Conference on Advanced Steels (ICASS), May 22-24, 2002 in Tsukuba, Japan (website: www.nims.go.jp/icass) with the co-sponsorship of the Iron and Steel Institute of Japan, the Korean Institute of Metals and Materials, and the Chinese Institute for Metals. At ICASS, achievements in the Ultra-Steel projects will be presented together with the latest progress in steel technology in the Asian countries where production and research activities in steel are the highest. ■

Further information on the above and related news items can be obtained by contacting: Dr. Toshiaki Kodama, National Institute for Materials Science, Sengen 1-2-1, Tsukuba 305-0047, Japan, Tel: 81.298.59.2302; Fax: 81.298.59.2301; E-mail: KODAMA.Toshiaki@nims.go.jp.