Y/DZ-2166

Automated Corrosion System in a Moist Environment

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Date of Issue: March 19, 1999

Abstract for Submission to:
22nd Aging, Compatibility and Stockpile
Stewardship Conference
Oak Ridge Y-12 Plant
April 27-29, 1999

Prepared by the
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
managed by
Lockheed Martin Energy Systems, Inc.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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Introduction

In an effort to assist researchers investigating the moisture-generated corrosion of metals and ceramics, a unique exposure system was developed. The initial goal of this system was to monitor corrosion ranging from a few monolayers at the outset of the corrosion process to high mass gains in more extensively corroded material. The new system uses a small robot arm for sample manipulation; gravimetric and Fourier transform infrared (FTIR) spectroscopy for corrosion-product determination; and a gas blending system to control the moisture content of the glove box in which the system is housed, as shown in Fig. 1. The system's computer control can be configured to coordinate the examination of as many as 20 samples by periodic weighing and FTIR scanning. The computer also performs such functions as data logging of the temperature and pressure of the system and of the flow rate and moisture content of the purge gas. One main benefit of the computer-controlled robotic system is its ability to monitor samples 24 hours a day with precision control; this reduces problems stemming from human error or inconsistency of human technique.

Fig. 1. Automated corrosion system with moisture generation system.

Construction and Operation

The central component of the system is the robot arm, shown in Fig. 2. The robot arm is a Microbot Alpha II manufactured by Questech Inc. The arm, which moves with 5 degrees of freedom, provides a more-than-adequate lifting capacity and speed and places the sample in almost any position needed. The programming of the robot arm is rather straightforward and allows for nearly 1000 programming steps, which far exceeds the corrosion system's needs. A controller on the robot allows for the nonvolatile storage of its program.

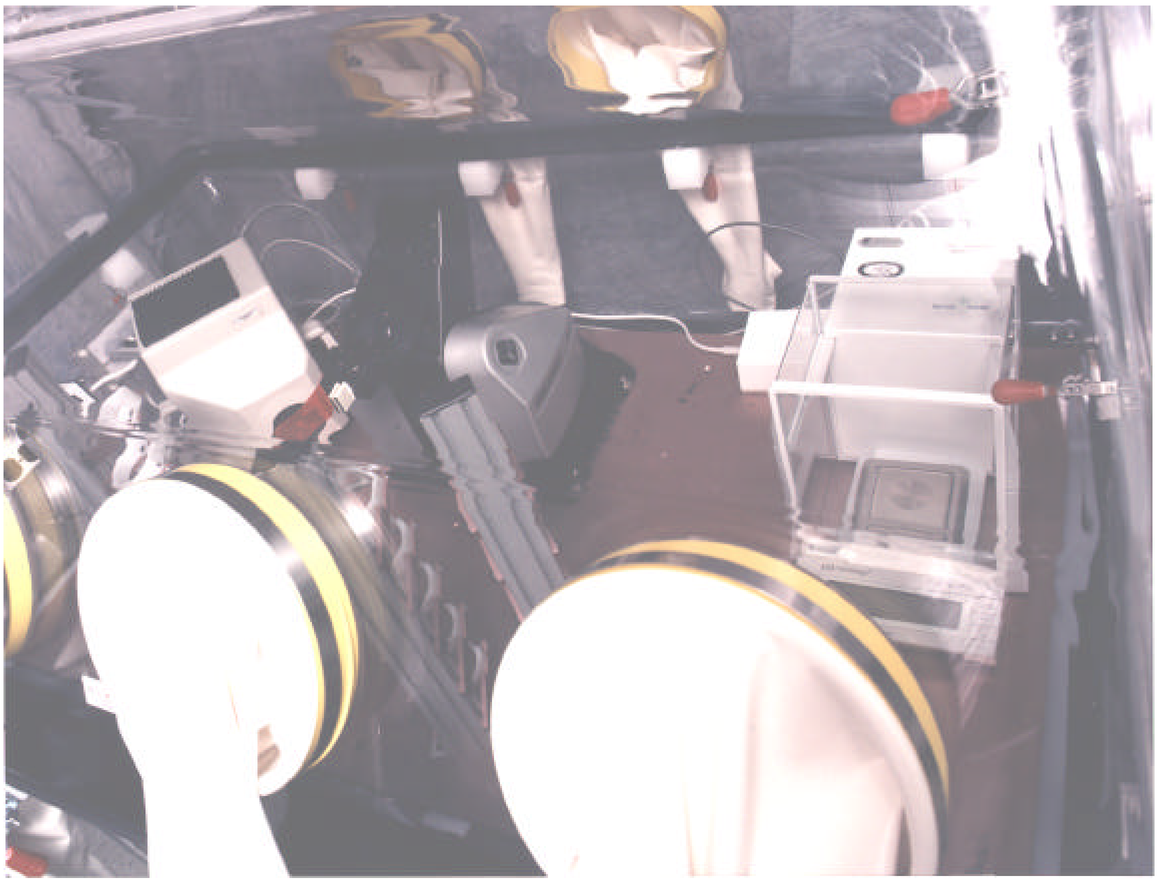

Fig. 2. Microbot robot, spectrometer, and balance.

Each 2-in.-disc-shaped sample is held in its own ultrahigh-molecular-weight-polyethylene (UHMW) cradle that suspends the sample with only three points of contact. UHMW was chosen because of its low weight and low absorption of moisture. Moisture uptake was of great concern because the uptake would cause an error in mass reading and would be a ready source of moisture that could alter the sample's corrosion rate. The shape of the holder is such that the sample is touched only at the three contact points; this allows for the free flow of the moist gas around the sample.

A Mettler AT-261 balance measures the sample's weight. This balance provides the necessary resolution for the samples initially chosen for testing and has full function capability through an RS-232 serial port. When a sample is to be weighed, a draft shield on the balance is closed and the balance is zeroed. Once the balance is zeroed, the draft shield is opened and the sample is placed on the weighing pan. Then the draft shield is closed, and the sample's weight is taken. Afterward the sample is returned to its station or presented to the FTIR for scanning.

The FTIR is an SOC-400, manufactured by Surface Optics. This unit is a self-contained spectrometer that is remotely controlled by a dedicated computer. The spectrometer's computer works in conjunction with the corrosion system's control computer. When the robot presents a sample to the spectrometer, the corrosion system's control computer initiates the scanning procedure in the FTIR's computer and waits for a confirmation of completion. The spectral data reside on the spectrometer's computer, but a record of the time and file name is maintained on the system's control computer.

Atmospheric control for the glove box is achieved with a custom-built gas blending system that supplies a steady purge-gas stream. The gas system delivers a relatively high flow rate of blended gas, ~10 L/min, with a user-selectable moisture content. The system was designed to accommodate dry feed gases such as argon, nitrogen, and air. To achieve moisture control a small, saturated moist stream of gas is blended with the bulk dry gas stream. Because moisture is always added to the stream to achieve control, the moisture content of the feed gas must be below the level of control. The gas system has been shown to maintain moisture control from 10 ppm to 1000 ppm. Other ranges are possible but have not been demonstrated. Figure 3 shows a schematic representation of the blending system. As shown, the feed gas stream splits: the bulk of the gas passes through a bulk flow controller, and a smaller stream passes through a flow controller and then through a low-volume leak control valve. The latter stream then passes through a water bubbler with a long path length to produce a saturated stream. The bulk stream and the saturated stream are blended together, and a small sample stream is fed to a General Eastern dew point hygrometer that measures the moisture content. The measurement is used as a process control value to regulate the flow of the gas stream fed to the bubbler. This system produces a dynamically controlled gas system that provides a controlled gas stream for long durations without drifts in moisture content. The user may choose to have multiple setpoints and selectively generate a stair-step moisture exposure.

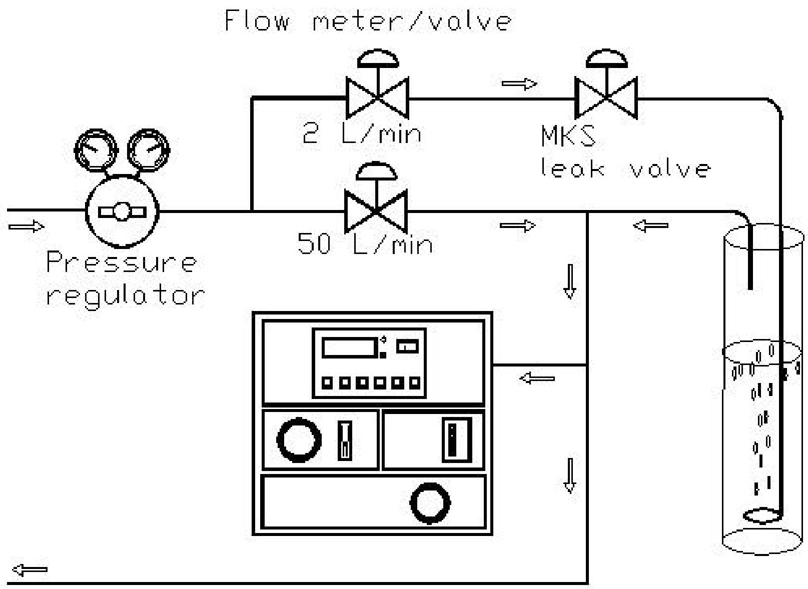

Fig. 3. Schematic representation of moist gas blending system.

Conclusion

A computer-controlled robotic corrosion system was developed to improve the process in which corrosion data were conventionally taken. Monitoring samples around the clock, this new robotic system offers two means of determining the corrosion products produced: FTIR spectroscopy and gravimetrics. A custom-built moist gas delivery system provides a long-term moist gas stream to consistently expose as many as 20 samples simultaneously. Computer control and data logging provide greater accuracy by reducing the opportunities for human error and inconsistencies.

Distribution

22nd Aging, Compatibility and Stockpile Stewardship Conference

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Y-12 Plant Records Services (3) 9711-5, MS-8169
[2 copies for OSTI and 1 copy for Central Files]