Chemically Bonded, Porcelain Enamel Coated Pipe for Corrosion Protection and Flow Efficiency

Liang Fan[1], Genda Chen[1], Signo T. Reis[2], Fujian Tang[1], Michael L. Koenigstein[2]

1. Department of Civil, Architectural, and Environmental Engineering
Missouri University of Science and Technology, Rolla, MO 65409-0030, United States
2. Pro-Perma Engineered Coatings, Roesch Inc., Belleville, IL 62226, United States

Main Objectives

The aims of this project are to explore chemically-bonded porcelain enamel powder coating for corrosion protection and safety of metallic pipes, and to develop a rapid field-applicable coating process for flow efficiency and cost reduction in the operation of metallic pipelines.

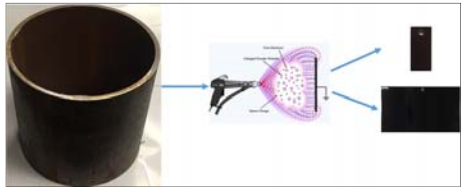

Figure 1. Coating Process.

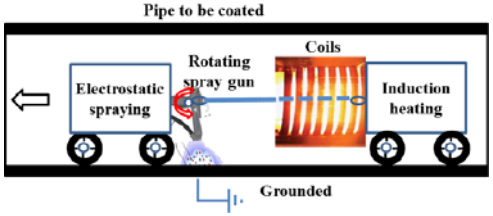

Figure 2. A conceptual design and schematic view of enamel powder spraying and heating system.

Project Approach/Scope

- **Optimization of enamel materials for durability and thermal compatibility with steel**
- **Enameling process for coating uniformity, surface roughness, and efficiency**
- **Characterization of enamel-coated pipes for microstructure, chemical adhesion on steel, and corrosion resistance**
- **System performance of *in-situ* enamel-coated pipelines- stress distribution under thermal, external and internal pressure, and stress corrosion cracking**

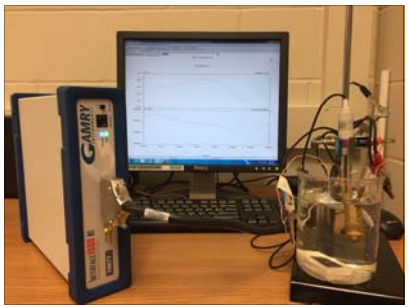

Figure 3. Corrosion test setup with the Gamry, 1000E Potentiostat/Galvanostat/ZRA system.

Figure 4. Corrosion tests in salt spray chamber.

Results to Date

- **The difference in the coefficient of thermal expansion between steel and enamel coating tends to favorably make the coating in compression during cooling.**
- **Enamel coating has amorphous structure with no crystalline phase observed.**
- **Enamel coating has a porosity of 12.7% and provides chemical bond with steel substrate through small Fe rich protrusion anchor points.**
- **Three enamel coating specimens showed consistent corrosion resistances.**

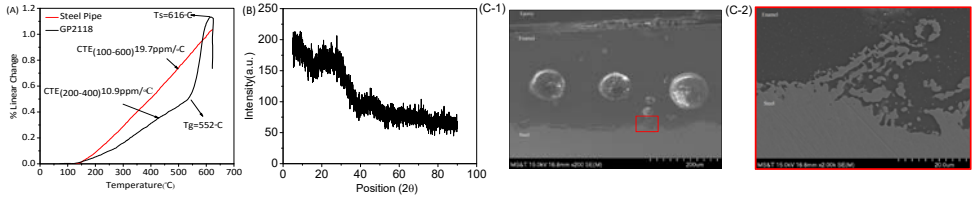

Figure 5. (A) Thermal properties of the coating and steel, (B) XRD patterns of the coating, and (C) cross-sectional SEM images of enamel coated samples with different magnification (1: 200× ; 2: 2000 ×).

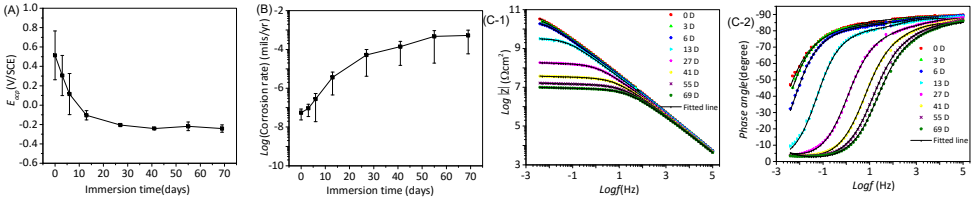

Figure 6. Corrosion test results of enamel coated steel samples in 3.5 wt.% NaCl solution for 69 days: (A) evolution of OCP, (B) change of corrosion rate, and (C) Bode plots (1: impedance; 2: phase angle).

Acknowledgment

This project is funded by DOT/PHMSA Competitive Academic Agreement Program.

Reference

Guskov, S., Application of powder coatings: old problems, new findings, new developments, Proceedings of the Powder Coating '96 Conference in Indianapolis, Indian, September 18, 1996. Construction and Building Materials, 112 (2016): 7-18.

Public Project Page

https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=631