ADVANCED COATING MATERIALS EVALUATIONS

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corrosion protection, coatings, polymers, polymer matrix composites, polyphenylene sulfide, flame spray application technology, biochemical processes.

PROJECT BACKGROUND AND STATUS

Corrosion and scale deposition continue to adversely affect geothermal plant operating costs, energy conversion efficiency, and utilization factors. To combat corrosion, portland cement-based materials are sometimes used as liners on brine piping systems, but the alkaline nature of the cements prevents their use with acidic fluids. Other conventional protective barrier materials such as epoxies, polyesters and acrylics, or metallic claddings, are limited by the thermal and/or hydrolytic stability of the plastics, and the costs for the metals.

Since the general utilization of high alloy steels is cost prohibitive for most geothermal plants, current practice is to attempt to minimize corrosion and scale deposition by plant design and subsequent operation that may not be optimum for energy conversion and fluid injection. For example, it is well known that lowering the pH of hypersaline brines can significantly reduce silica scale deposition. This would allow greater temperature differentials across the heat exchangers, reduce plant size and complexity by elimination of the clarifiers, and decrease the amount of potentially toxic waste sludges that must be disposed of at ever increasing costs. Unfortunately, the lowering pH option is constrained by increased corrosion problems that currently can only be solved by the use of prohibitively expensive construction materials. Low cost, acid resistant and hydrothermally stable coating systems that can be used for new plant construction and for the retrofit of existing plants are needed.

Recently, the technical and economic feasibilities for the use of biochemical processes for the treatment of geothermal wastes and mineral recovery have been demonstrated at Brookhaven National Laboratory (BNL). As a result, considerable industrial activity is underway as cost-shared efforts with BNL. Portions of these processes operate with low pH (~ 1), high chloride content brine sludges at temperatures up to 80°C. To make these processes cost effective, low cost and corrosion resistant materials of construction are needed.

This task was started in FY 1995 and is being performed as a cooperative cost-shared effort with geothermal energy firms.

PROJECT OBJECTIVES

The objective of this task is to reduce the construction and O&M costs for geothermal processes. This is being accomplished by the optimization and field testing of polymers and polymer matrix composites, developed in other Geothermal Materials Development tasks, as corrosion protection systems for power plant applications.

Technical Objectives

- Develop and field test low cost, acid resistant and hydrothermally stable corrosion protective coating systems that can be used for the retrofit of existing plants and for new plant construction.

Expected Outcomes

- Significant reductions in plant construction costs and complexity by elimination of the need for clarifiers.
- Increased electric generation efficiency and plant utilization factors.
- Enhanced environmental acceptance due to reductions in solid waste generation rates.

APPROACH

The project objectives are being met by the performance of a multi-phase effort that is cost-shared with geothermal energy and/or other industrial partners. In Phase 1, specific coating needs are identified and performance specifications defined. Phase 2 consists of the selection of potential candidate polymer and composite systems developed in other program tasks, and optimization of them for the specified end-use application. Field testing of coupon size samples is conducted in this phase of the effort. Contingent upon these results, potential commercial sources and development partners for the technology are identified in Phase 3. Field testing of coated prototype and full-scale process components at the Salton Sea KGRA and other locations is being conducted in Phase 4. Contingent upon these results, Phase 5 will consist of economic studies and the completion of technology transfer.

RESEARCH RESULTS

As of the end of December 1996, a number of potential polymer and polymer-matrix composite coating systems were being investigated. These included polyphenylene sulfide (PPS), polyphenyletheretherketone (PEEK), ethylene metacrylic acid, and acrylic epoxy polymers; and ethylene tetrafluoroethylene copolymer. In attempts to enhance abrasion resistance, metallic zinc phosphate compounds and nickel aluminide alloys were being evaluated as coupling systems between metal substrates and the polymer topcoats. Methods such as plasma flame spray, chemical vapor deposition and physical vapor deposition were being considered as technologies for placement of the coatings. Test environments include hypersaline brine at 300°C and pH 1 biochemical reagent solutions at 80°C.

A cost-shared effort with the CalEnergy to field test PPS-coated pipe is in progress. Two 61-cm-long sections of 25-cm-diam pipe were shipped to them for field testing at one of their Salton Sea power plants, but to date the test has not been started. The inner surfaces of both pipe sections were first cleaned by grit-blasting. This was followed by the application of a BNL developed zinc phosphate conversion coating, the purpose of which is to enhance bonding between polymer-based topcoating materials and the metal substrate. It also provides corrosion protection. One pipe section was then coated with two layers of PPS polymer. This is an extremely acid resistant, high temperature (~300°C), highly crosslinked material.

A second pipe has one layer of PPS and an outer layer of a PPS-silicon carbide composite over the zinc phosphate. Our goal with the composite is to improve the abrasion resistance of the PPS. If the PPS systems are shown to be durable, flame spray applied PPS is a likely candidate for evaluation since the technology is suitable for field use. Therefore, it may be possible to retrofit existing pipelines.

Testing to identify suitable materials of construction for components used in processes for the biochemical treatment of geothermal wastes, was initiated at BNL. Low cost materials that are resistant to low pH (~1), high chloride solutions at temperatures up to 80°C must be available if the processes are to be economically viable. In these studies, 316L stainless steel is being used as a reference material. The control data indicated that after exposure for 10 weeks, samples fully immersed or totally in the vapor zone did not show any visible corrosion. Partially immersed samples exhibited pitting corrosion above the liquid level. Evaluations of polymer coated mild steel coupons under similar conditions have been initiated. Ethylene metacrylic acid polymers and ethylene tetrafluoroethylene copolymer, both applied using flame spray technology, are being tested. To date after exposure for 10 weeks, no deterioration has been detected. Similar tests using solutions containing Thiobacillus ferrooxidans are also under way.

FUTURE PLANS

FY 1996 initiated laboratory testing of industry-supplied metal coupons that were coated with BNL selected corrosion protection systems will be completed. Based upon these results, field testing of coated pipe sections and other components will be initiated at the Salton Sea, The Geysers and in biochemical process pilot plants constructed by commercial firms.

INDUSTRY INTEREST AND TECHNOLOGY TRANSFER

Organization	Type and Extent of Interest
CalEnergy Inc.	Research collaborators for corrosion protection for plant components. Potential user of technology.
Pacific Gas & Electric	Research collaborators for corrosion protection of vent gas blowers, dry cooling tower components, turbine blades, and rotor housings. Potential user of technology.
CET Environmental Services, Inc.	Operators of biochemical treatment process facilities.

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