TITLE: Novel Nanocrystalline Intermetallic Coatings for Metal Alloys in Coal-fired Environments

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1. ABSTRACT

Program Introduction: Rationale and Objective

This research program aims to develop a high temperature corrosion resistant coating for metal alloys used in coal-fired environment. The coating consists of *nanocrystalline* intermetallic alloys, specifically iron aluminide (Fe_3Al) and nickel aluminide (NiAl), which are well known for having superior high temperature strength and corrosion resistance. The program will develop *a new and novel process* that combines the advantages of several coating processes including thermal spray, CVD, and PTA cladding to deposit dense, thick, and phase pure intermetallics and their composite coatings. The coatings will be applied on ferritic and austenitic steels and nickel based superalloy substrates.

Overall scope of the proposed program involves: (1) The development of a new process for applying nanocrystalline intermetallic alloy based coatings, and (2) The testing of the coatings in a laboratory simulated coal-fired environment. The objective is to develop a new coating technology, that has superior corrosion resistance and creep strength at high temperatures than the existing coating technologies, for advanced coal-fired power generation systems.

Accomplishments Achieved During the Current Period of Performance

A novel in-situ reaction process for depositing high temperature corrosion resistant coatings,

including iron aluminide coatings on steel substrates or nickel aluminide coating on Ni-alloy substrates, was developed. In this process, aluminum powder is fed through a plasma transferred arc (PTA) torch onto the steel or Ni-alloy substrate surface. Experimental results demonstrated that the iron aluminide or nickel aluminide coating was formed by an in-situ reaction between the aluminum powder and the steel or Ni-alloy substrate. Aluminide coatings prepared under optimum conditions were porosity-free and metallurgically bonded to the steel or Ni-alloy substrate. It is expected that the principle demonstrated in this process can be applied to the deposition of other intermetallic and alloy coatings.

Iron aluminide coatings, which were porosity-free, phase-pure and metallurgically bonded to steel substrates, were deposited on half-circle-shaped stainless steel pipes for field-testing of the corrosion resistance of the obtained coatings in realistic industry environment. The field-test started in September 2007, where two coated half-pipes were mounted as shields for boiler pipes in a coal-fired boiler of a power plant.

Plans for the Remaining Period of Performance

- Fulfills the field tests to evaluate the practical performance of iron aluminide coated stainless steel pipes in power plant.
- Optimizes the coating parameters for depositing nickel aluminide on Ni-alloy.

2. LIST OF PUBLISHED JOURNAL ARTICLES, CONFERENCE PRESENTATIONS, US PATENTS/PATENT APPLICATION(S) AND STUDENTS RECEIVING SUPPORT FROM THIS GRANT

Journal Articles
Iron aluminide coating by an in-situ reaction process, P. Fan, E. Riddle, Z.Z. Fang and H.Y. Sohn, Surface and Coating Technology, 2008, submitted

Conference Presentations
Iron aluminide coating produced by plasma transferred arc process, P. Fan, E. Riddle, Z.Z. Fang, H.Y. Sohn and M.D. Clark, 8th International Conference on Trends in Welding Research, 2008, submitted.

US Patent Applications
Processes for in-situ coating of metals, Z.Z. Fang, H.Y. Sohn, P. Fan and E. Riddle, U.S. Patent Application, 2007, Serial No. 61/018,162.

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