TECHBRIEF

HIGH-PERFORMANCE CORROSION-RESISTANT HIGH-ENTROPY ALLOYS

OPPORTUNITY:

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) developed designs, manufacturing processes, and corrosion property validations of new high-performance corrosion-resistant high-entropy alloys that are superior to and less expensive than existing alloys and demonstrate improved resistance to corrosion, including pitting corrosion in harsh environments and sea water.

CHALLENGE:

Metals and alloys used in sea water or acidic aqueous environments are prone to various forms of corrosion, including pitting and/or crevice corrosion because of the presence of aggressive salt, such sodium chloride (NaCl). Pitting and crevice corrosion can serve as initiation sites for developing cracks that will lead to catastrophic failures of the metallic components. The current solution to this problem is to coat the metals with nickel (Ni)-based superalloys such as Hastelloy® C276. Hastelloy®, which is very expensive.

OVERVIEW:

NETL addressed the challenge of developing a design, manufacturing process and corrosion property validations for alloy compositions that consist of main constituent elements Ni, Fe, Cr, Co, and Mo. The alloy design methodology is based on the concept of high entropy of mixing and uses CALculation of PHAse Diagrams (CALPHAD) calculations. The resulting solid solution alloys have multiple principal elements that contribute to high entropy of mixing. The alloys consist of iron in large amount to reduce the cost. In addition to overcoming cost challenges, the new alloys can improve resistance to localized corrosion in aggressive service environments increasing the service life time of components.

The novelty of the high-entropy solid solution concept, optimized manufacturing route, improved corrosion resistance, and reduced cost constitute the main features of the innovation and approach of the technology to the identified challenges. The alloy compositions are new and have not been used before in industries or reported by others in the open literature. The manufacturing route is optimized for these alloys to achieve homogenization.

(continued)

www.NETL.DOE.gov

ADVANTAGES:

The new alloys have use as more effective and lower cost coatings to protect metals and alloys from corrosion in extreme environments where corrosion is a major concern including sea water. The alloys certainly can be manufactured as bulk structural components that demand both high ductility and excellent corrosion resistance. In addition to overcoming cost challenges, the new alloys can improve resistance to localized corrosion in aggressive service environments increasing the service life time of components.

APPLICATIONS:

Pitting and crevice corrosion of structures operating in extreme environments and at sea, can serve as initiation sites for developing cracks that will lead to catastrophic failures of the metallic components costing industries time and money. The alloy innovation can provide:

- A high-entropy solid solution concept for component coatings
- Optimized manufacturing routes
- Improved corrosion resistance
- Reduced costs

PATENT STATUS:

- U.S. Patent Provisional Application No. 62/814,402 titled, *"High Performance Corrosion-Resistant High-Entropy Alloys"*
  Filed 03/06/2019

  Inventors: Jeffrey Hawk, Paul Jablonski, Malgorzata Margaret Ziomek-Moroz, Joseph Tylczak, Michael Gao, Alvaro Rodriguez

  Ref No. 18N-09

NATIONAL ENERGY TECHNOLOGY LABORATORY

FOR MORE INFORMATION:

Jessica Lamp
Technology Transfer Program Manager
Jessica.Lamp@netl.doe.gov
412.386.7417

Customer Service:
1.800.553.7681

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412.386.4687

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304.285.4764

1450 Queen Avenue SW
Albany, OR 97321-2198
541.967.5892