High Performance Internal Surface Coatings for Elevated Temperature Corrosion and Wear Resistance

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An enabling new coating manufacturing technology platform has been developed capable of coating industrial components previously deemed uncoatable due to their complex shape, their processing temperature-limiting composition, or both. The new coating processes cost-effectively allow access to a broad range of coating formulations and microstructures, to enable broad-based engineerable properties and performance benefits with thicknesses ranging from 50 to 5,000 µm on internal surfaces. Coating developments completed for the highest temperature, most aggressive service conditions todate of >1100^{o}C, 5+ years continuous cyclic service (petrochemical-olefins), have been made possible using multicomponent coatings with thicknesses of 200 to 1,000 µm to meet the range of required properties. Uniformity of deposition is good to excellent, depending on component shape complexity, with tubular shapes achieving better than 10% uniformity both radially and longitudinally. Coating temperature is tunable for compatibility with base alloy properties and/or limitations. This paper will focus on the key aspects of coating systems engineered, developed, and in late stage commercial-scale Beta testing, as well as new areas currently under development for identified needs in existing and emerging energy conversion systems.

Developed Coatings and Surfaces for Energy-intensive Processes

1. Advanced Catalytic Coatings with high temperature corrosion resistance for the “Catalyzed-assisted Manufacture of Olefins and Hydrogen (CAMOL)”: Highly-engineered coating systems have been developed for petrochemical furnaces used to manufacture olefins (primarily ethylene and propylene) with operating temperature exceeding 1100^{o}C under aggressive corrosive conditions inclusive of cyclic carburizing and oxidizing conditions, and significant sulfidizing and halogen-based corrosion potential. To achieve commercial viability, these coatings incorporate 21 chemical, physical and thermo-mechanical properties and have been in field service for 3 years (as of Sept. 2009) with good to excellent results against the range of targeted benefits. One of the properties of these coatings is to sustain an outermost

catalytic-gasifying surface for carbonaceous material, effectively maintaining coke (fouling)-free performance across a broad range of hydrocarbon feedstocks and low oxidizing conditions. The targeted benefits are extensive and include a 10-20 fold increase in furnace operating runlength (referenced to an average of 20-40 days furnace online-time in the olefins industry prior to a decoking cycle; enabled to 1-2 years online-time with the use of the CAMOL coatings). The coatings additionally provide significant improvements in furnace efficiency and profitability through reductions in overall operating temperature, energy use and GHG emissions per unit of production. CAMOL targets a 5-25% reduction in energy and emissions per tonne of olefin produced depending on specific furnace operation (referenced to 20-40 GJ of energy required to manufacture one tonne of ethylene and generating 1-2 tonnes of CO_2 per tonne of ethylene produced). CAMOL products will be available commercially in 2009.

2. High Temperature Hot Erosion Coatings with low corrosion surface loading to 1050^{o}C. Prototypes are in Beta testing and are projected to be available commercially in 2010.

3. Low-Medium Temperature Wear-Corrosion Coatings (<900^{o}C) with hardness of ~1200 H_v, high fracture toughness and good ductility, with corrosion resistance equivalent to CRAs. Coating formulations have been developed to achieve both strong wear resistance coupled with CRA-level corrosion resistance. Prototypes are in Beta testing for commercialization in 2010.

Coatings and Surfaces Under Development for Energy-conversion Systems

- Hot Erosion coatings for higher temperature service (>1050^{o}C) and higher corrosive surface loadings.
- Wear-corrosion resistant coatings with hardness >1300 H_v, high fracture-toughness and ductility, and high corrosion resistance up to 1,000^{o}C.
- High heat-transfer, high-temperature alloy (HTA) tubes with internal surface area equal to or greater than outer surface area, with high corrosion resistance and a coke-free internal surface for hydrocarbon processing at elevated temperatures.
- Elevated-temperature, coke-free process containment surfaces engineered for enabling catalyzed conversion of methane to hydrogen and light olefins.
- Elevated temperature, coke-free surfaces for enabling catalyzed conversion of hydrogen and carbon dioxide to methanol (reverse-SOFC and other approach).